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USSR Report

RESOURCES

(FOUO 21/79)

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ELECTRIC POWER AND POWER EQUIPMENT

HYDROELECTRIC POWER STATION MODERNIZATION AND REDESIGN

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, Oct 78 pp 1-3

[Article: "Modernization and Redesign of Hydroelectric Power Stations--A Prime Direction in Making Them More Efficient"]

> [Text] "...Gains in production capacities must be scored first of all through the placement of new equipment in enterprises, modernization of equipment and the carrying out of industrial-engineering measures aimed at higher output of high-quality products at smaller outlays and in shorter schedules. Design-obsolescent equipment must be replaced faster...."
> (From "Guidelines for the Growth of the USSR National Economy in 1976-1980")

The 25th CPSU Congress determined that one of the paramount tasks in the growth of the national economy is gains in production capacities through the placement of new equipment in enterprises, modernization of equipment and the carrying out of industrial-engineering measures aimed at higher output of high-quality products at smaller outlays and in shorter schedules, as well as faster replacement of design-obsolescent equipment.

Using hydropower resources effectively demands steady improvements in equipment operating at hydroelectric power stations, with allowance for the latest advances in power machine building. Requirements on the reliability and safety of active hydroelectric structures are continuing to grow more stringent, for the efficient integrated use of water resources in the national economy. At present about half the installed GES capacities (23 million kW) have been active for longer than 10 years, and about 6 million kW--for longer than 20 years; the biggest part of these GES is in the European territory of the country (about 13 million kW). Conditions for the long-term growth of electric power engineering and the mounting demand for flexible energy sources have pushed redesigning and modernizing of active GES as one of the prime directions for making power systems more efficient.

The fundamental prerequisites for redesigning active GES include higher load chart peaks, the deficiency in the fuel and power balance, a change in the water-management conditions at a number of hydroelectric power stations, the stronger regulating importance of GES in power systems and the need to reduce all kinds of outlays in operating GES. Among the measures leading to this goal are the following: modernization or replacement of the main hydropower equipment that is physical worn-out or that has technical characteristics that are low compared with today's level; elimination of restrictions on the operation of equipment and hydroelectric facilities; restoration of regulating capacities of reservoirs and basins for flow control and so on; carrying out technical measures to cut head losses in incoming and outgoing GES conduits, boost GES head, optimize hydroelectric installation regimes and the like; and expand active GES by putting in extra hydroelectric installations.

First in importance is the question of redesigning the GES in the European part of the USSR. Until recently GES have here met the peak and, in part, the semipeak zones of the load chart of the intertie power systems. In meeting the semipeak zone of the load chart steam-electric power stations have also been involved, above all, the least economic condensation power stations. This solution was technical feasible and economically justified. In the future, however, the situation will change in a major way. The opportunities of constructing new efficient GES in the central regions of the USSR have been practically exhausted but for the Caucasus and the northern regions. The proportion of GES in the makeup of the generating capacities in the European part of the USSR in the long term will go down from 14-15 to 10 percent. So a correct solution to the problem of redesigning (expanding) active GES becomes very important.

In the Ninth Five-Year Plan redesigning went on at the Volzhskiye GES imeni XXII s"yezd KPSS and imeni V. I. Lenin, Novosibirskaya, Bratskaya, Kakhovskaya and others. At the Bratskaya GES the replacement of stator windings in the hydroelectric generators made it possible to increase the installed capacity of each installation by 25 MW, and for the entire GES--by 400 MW. Redesigning the Novosibirskaya GES hydroelectric generators made it possible to raise the GES capacity from 400 to 455 MW. The Leningrad Metals Plant Association has modernized hydraulic turbines at a number of active GES, in particular, the mechanisms for rotating runner blades in rotating-bladed turbines, runners of radial-axial and bucket turbines and guide vane assemblies and guide bearings. A complex of measures was developed and put into effect to lower cavitation damage, including at the Bratskaya GES. The Khar'kov Turbine Plant delivered new hydraulic turbine runners to the Chiryurtskaya GES-1, the Ordzhonikidzevskaya, Krasnopolyanskaya and other GES. The plant is engaged in studies on modernizing runners in the Vilyuyskaya GES and in modernizing elements of the flow-through channel of the reversible hydraulic machine of the Kiyevskaya GES.

Large redesign operations haye been carried out for higher reliability and safety of hydroelectric installations. Metal conduits are under redesign at the Krasnopolyanskaya GES and the earthen dam at the Shirokovskaya GES; redesign of the spillway dam of the Volkhovskaya GES and other structures has been completed. A large volume of redesigning mechanical equipment of the GES has been done by the Lenenergo Power Administration.

Expanding active GES with the construction of new machine halls and the placement of additional hydroelectric installations has a special role to play. Experience in new construction at the active GES was gained at the Dneprovskaya GES imeni V. I. Lenin and at the Kegumskaya GES.

Modernization of control with a conversion to automated systems with control computer complexes is yielding a substantial benefit in bettering the use of GES in power systems and making them more reliable. The automated industrial process control systems, including subsystems of diagnosis, management of normal and emergency regimes, control over equipment operation and condition and over hydroelectric installation operation and condition and other facilities have been placed in service at the Krasnoyarskaya, Votkinskaya, Saratovskaya and several other GES.

At present an integrated plan for redesigning and modernizing active GES is being drafted in the USSR Ministry of Power and Electrification. Preliminary calculations show that by purposeful redesigning and modernizing of equipment and the carrying out of several other measures, it is possible to increase the total capacity of active GES by 5.6 million kW and GES energy generation by 4.7 billion kWh, including by 3 million kW and by 1.1 billion kWh, respectively, in the European part of the USSR. These proposals for the power stations and power systems make it possible to estimate approximately the energy benefits from different directions in GES redesigning and modernizing (see Table). The tabular data do not reflect the benefits that can come from the integration automation of the GES, extension of the installation operating regimes, pump (or pump-turbine) operating regimes, the adoption of automated industrial process control systems and the like. At a series of GES physically worn-out and design-obsolescent equipment is already going on (Volkhovskaya, Krasnopolyanskaya and other GES). Redesigning is scheduled for both hydroelectric installations as a whole (Volkhovskaya, Mingechaurskaya, Kegumskaya and Nizhnetulomskaya GES) and their individual assemblies. Thus, for example, stator windings are scheduled for replacement at the Volzhskaya GES imeni XXII s"yezd KPSS, the Rybinskaya GES and other GES. Redesigning of the cooling system of power transformers must be done at the Volzhskiye GES imeni XXII s"yezd KPSS and imeni V. I. Lenin. Redesigning of auxiliary equipment with the adoption of the synchronous compensator mode must be effected at the Volzhskaya GES imeni V. I. Lenin, Kamskaya and other GES. Equipment redesigning plans at the stages of schematic critical analysis, technical and economic substantiation and technical plans are already available for a number of active GES (Volkhovskaya, Nizhnesvirskaya and Mingechaurskaya GES).

Мероприятия (a)	Рост установленной мощности, млн. квт (b)		Увеличение выработки электроэнергии, млрд. квт·ч (c)	
	СССР (d)	Европейская территория (e)	СССР (d)	Европейская территория (e)
Расширение гэс (f)	3,6	1,7	0,9	0,2
Улучшение использования водотока путем реконструкции гидросооружений (h)	Не оценивался (g)		1,1	0,2
Комплексная замена устаревшего гидроэнергетического оборудования (i)	0,7	0,6	0,4	0,3
Замена рабочих колес гидротурбин (j)	0,6	0,4	1,6	0,1
Реконструкция электротехнического оборудования (k)	0,7	0,4	0,7	0,3
Всего (l)	5,6	3,1	4,7	1,1

Key:
- a. Measures
- b. Gain in installed capacity, million kW
- c. Gain in electric energy generated, billion kWh
- d. USSR
- e. European part of the USSR
- f. Expansion of GES
- g. Not estimated
- h. Improvement in use of water flow by redesigning hydropower installations
- i. Integrated replacement of obsolescent power equipment
- j. Replacement of hydroturbine runners
- k. Redesigning of electrotechnical equipment
- l. Total

One way of increasing capacity and generation of electric energy at active GES is raising the elevation readings of the normal backwater level of the reservoirs. These measures are advisable in sparsely settled regions of Siberia and the Far East and in the mountainous regions of Central Asia. Thus, for example, there is a decision to raise the elevation reading of the normal backwater level at the Vilyuyskaya GES by 1.5-2 m. Raising the reservoir level at large GES in the European part of the USSR involves, as a rule, heavy material outlays and cannot be justified by the interests of power engineering alone.

Growing out of the demand for flexible capacity by the power systems of the European part of the country, the GES of the Volzhsko-Kamskiy and Dneprovskiy cascades must become first-priority projects for redesigning.

The design critical analyses, in finding out whether it is worthwhile to redesign GES, must place the most important significance on accounting for the requirements on the operating regimes of GES and restrictions on the energy water users and the water users.

A study must be made of the possibility and effectiveness of using reversible hydroelectric installations and even individual pump installations at existing GES. When this is done, existing GES will be converted to GES-GAES. The inclusion of pump and reversible equipment at GES will make possible the guaranteed release of reservoirs. Additional capital investments for modernizing GES to convert them to GES-GAES must be recouped by savings in operating costs in the power system.

When determining the economic and technical soundness of GES modernization, there is a need for an integrated approach that bears in mind the specific conditions and standing of each GES in the power system. Among the most important results of modernization are the following: raising the reliability of electric power supply; increasing equipment efficiency; increasing use efficiency of the GES in the cascade; lowering operating and repair outlays; and lowering the size of the operating work force.

When determining the effectiveness of GES modernization, there is a need, moreover, of providing an economic evaluation of the benefits gained by improving equipment use, for the specific power system overall.

Highest of all is the effectiveness of expanding active GES with existing reservoirs and main water conduits. The specific cost of 1 kW of additional capacity at the expanded GES is 2.5-3 times lower than at the new hydroelectric power stations.

And in order to perform the prime task of GES redesigning and modernization with the highest benefits, the following are necessary:

developing a long-term program of redesigning active GES

determining the assignments for manufacturing industries in designing and manufacturing the main equipment for the redesigned GES

organizing the manufacture of spare parts and improvement equipment assemblies at the enterprises of the USSR Ministry of Power and Electrification

allocating needed reserves and funds for carrying out redesigning work and ensuring that this work is brought up to design ratings improving the methods of determining the economic effectiveness of capital investments in the redesigned and modernized projects.

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ELECTRIC POWER AND POWER EQUIPMENT

SCIENTIFIC-TECHNICAL PROBLEMS IN BUILDING SAYANO-SHUSHENSKAYA GES

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 2, Feb 79 pp 1-6

[Article by L. P. Mikhaylov and M. F. Skladnev, candidates of technical sciences and Yu. A. Grigor'yev, L. K. Domanskiy, A. I. Yefimenko and M. G. Aleksandrov, engineers]

[Text] The Sayano-Shushenskaya GES is a hydropower structure on the Yenisey River unique in size and complexity of construction; it is part of the Sayanskiy hydropower complex (including also the Maynskiy hydropower station, a counterregulating complex). The GES under construction will become the power base for the growing Sayanskiy territorial-industrial complex.

Constructing the Sayano-Shushenskaya hydroelectric power station required organizing on a large scale scientific investigations, experimental and design developments for making reliable, economic and operationally convenient structures and equipment. The complexity of the problem made necessary an integrated approach to handling scientific-technical tasks that emerge in designing and erecting the hydropower station and in making its equipment. Prominent in the organizational and engineering solution to this problem is a new mass form of socialist competition--an agreement on creative scientific-technical cooperation among Leningrad organizations taking part in building the Sayano-Shushenskaya GES, aimed at the fastest possible solution to scientific-technical problems and putting them into application. The agreement's main purpose is cutting back on the construction schedules of the Sayano-Shushenskaya GES, with high work quality through the accelerated commissioning of its hydropower installations, reduction in material consumption and in construction costs, in making the latest equipment and in upgrading the technology of construction practices.

This initiative of the Leningraders, sustained by the Sayano-Shushenskaya GES builders, was approved and recommended for wide acceptance by the CC CPSU and was highly evaluated by the General Secretary of the CC CPSU, comrade L. I. Brezhnev.

Agreement 28 became the antecedent of a new form of inter-industry organization of the integrated development and building of large national-economic projects.

The hydropower complex of the Sayano-Shushenskaya GES includes: an arch-gravity dam more than 240 m high, with a crest length of 1066 m, about 8.5 million m^3 of concrete; spillway structures designed for admitting discharge flows of 13,500 m^3/s; a hydroelectric power station with a total installed capacity of 6400 MW, with 10 hydropower installations capable at heads higher than the rated head of generating power up to 720 MW each; and an open 500 kV distribution system.

The Sayanskoye reservoir, 31 billion m^3 in size, stretches 300 km upstream along the river and covers its rapids section. The colossal potential of the Sayano-Shushenskaya GES, originating from the volume of the available capacity prism of the reservoir of 15 billion m^3, predetermines its leading role in the Intertie Power System of Siberia as a regulator of energy and power on a daily or annual profile, as well as the required reserve. Building the Sayanskoye reservoir permits moving freight and passengers to the Tuvinskaya ASSR by water. Over the long term, after construction of a ship elevator as part of the hydropower complex, through navigation will be possible on the upper Yenisey from Krasnoyarsk to Kyzyl.

The Sayano-Shushenskaya GES, by regulating the river flows during the high-water period, lessens flooding damage to a considerable extent. For the Sayano-Shushenskaya GES to meet the peak part of the power demand load in winter, prevent the unfavorable action of rapid oscillations in flows through the GES turbines on the conditions in the tailwater, meet the demands of non-energy water users and to protect the environment, 23 km from the GES the counterregulating Maynskiy hydropower station is under construction downstream along the Yenisey River; its reservoir will provide a uniform admission of water into the tailwater section. With the commissioning of the Sayano-Shushenskaya GES, conditions will improve for flow regulation and more electric energy will be generated by the Krasnoyarskaya GES.

Drawing up the plans for structures and equipment of the Sayano-Shushenskaya GES, unprecedented in domestic and foreign experience in hydroelectric power construction, posed a complex engineering and technical and scientific problem.

Underlying the dam plans were the latest achievements in Soviet hydroelectric engineering science. More than 40 dam design variants were examined during preliminary developments. To substantiate the profile, calculations were conducted by the trial-load method and by the method of thin-shell theory specially developed in Lengidroproyekt, as well as studies at the VNIIG imeni B. Ye. Vedeneyev on large-scale (1:125) models unique in their accuracy of reproducing the design features of the dam and the foundation geology. And consideration was given to the sequence of dam erection, the effect of technological openings, construction joints and so on. With fragmentary models, in the VNIIG imeni B. Ye. Vedeneyev and the LTA [Leningrad Foresty Engineering Academy] imeni S. M. Kirov, a study was made of the stressed condition of the dam weakened by the openings of the spillways and the turbine conduits, the effective of dispersed reinforcement on crack formation in the concrete and its thermally stressed state. These investigations carry high theoretical and practical importance for future designing and construction of similar structures.

The stressed state of the dam is characterized by the high level of compressive stresses in the concrete, reaching 9-11.5 megapascals (up to 115 kg/cm^2) on the downstream face and on the side abutments; tension in the upstream face higher than 1 megapascals (10 kg/cm^2) is allowed.

A new theory, developed in the VNIIG imeni B. Ye. Vedeneyev, of long-term concrete strength in the complex stressed state made it possible to achieve zonal distribution of the concrete and also to recommend concrete of grades 200, 250 and 300 instead of 250, 350 and 400 required under ordinary rules, which means sizable cement savings. Slag additions were widely used in selecting concrete compositions; this made it possible to reduce the content of clinker constituent in the main volume of the dam concrete to 120-150 kg/m^3. From the extensive studies at the VNIIG imeni B. Ye. Vedeneyev, it was also projected to use the flue ash from steam-electric power stations in the concrete mix. This measure will permit an additional reduction in the outlay of the clinker constituent by 10-15 kg/m^3.

Calculations of the total dam stability jointly with the adjoining rock massifs were conducted on the basis of a careful analysis of engineering-geological conditions (with allowance for the direction of cracks in the massif), according to a special method developed in Lengidroproyekt with allowance for the domestic and foreign experience in dam-building.

A most complex task in the designing of the Sayano-Shushenskaya GES was the treatment of problems associated with the absorption of energy from floodwater and construction runoffs in the tailwater. Worldwide construction practice knows of no counterpart structure where such a large head is combined with enormous runoff flows. Under the adopted scheme of regulation, the maximum calculated inflow volume with a confidence level of 0.01 percent is equal to 25,000 m^3/s is transformed in the reservoir, given favorable opening of the locks and forcing of the level by 4.5 m. This makes it possible to lower the regulated flow entering the tailwater to 15,900 m^3/s, including 13,600 m^3/s through the spillways. Ordinary spring floods accumulate in the reservoir, and the flows are passed through the GES turbines or are partially discharged through the spillway openings without forcing the headwater level [UBV]. In the construction period the runoff flows through the dam are close to the operating flows and can reach 13,100 m^3/s.

Analysis of the advantages and disadvantages of the numerous variants of absorbing flow energy with allowance for the results of widely arranged hydraulic studies on models in the VNIIG imeni B. Ye. Vedeneyev and in the NIS [scientific research sector] of Gidroproyekt with the participation of the Leningrad Polytechnic Institute imeni M. I. Kalinin made it possible in the setting of the restricted site width to select the reliable design of the spillway structures ensuring a fairly quiescent flow regime in the tailwater of the GES in both the construction and the operating periods (Fig. 1).

Under the adopted and executed variant, spillway structures consist of deep openings located in several tiers along the dam height (the lower two tiers are for passing flows during the construction period) and an apron shaft up to 35 m deep with a length of more than 100 m, where the energy of the flow falling from a height of more than 200 m and at rates of up to 55 m/s (Fig. 2) is absorbed. The foundation, longitudinal walls and the downstream apron wall of the shaft are calculated for static and dynamic loads of the flow spilling down the downstream face and carrying energy of more than 25 million kW. On losing its excess energy in the apron shaft, the water will enter the tailwater without scouring the river bottom and banks and not forming obstacles for the operation of the hydroelectric power stations. The required strength and cavitation stability of the spillway face of the dam and the apron shaft structures are ensured by a series of special measures, including the pouring of cavitation-resistant concrete and by artificial aeration of the flow.

The spillway openings are equipped with gates designed by the Lengidrostal' special design office, operating under heads of about 100 m, made by using high-strength steel and new antifriction materials with low coefficients of friction. Maneuvering of the gates of the bottom construction openings is done with a 7.1 meganewton load-capacity crane with an original system of pivoting on special jacks. The gates are designed after interdisciplinary hydraulic and strength investigations at the VNIIG imeni B. Ye. Vedeneyev, the Mosgidrostal' special design office and the NII elektrosvarka [Scientific Research Institute of Electric Welding] imeni B. Ye. Paton and the Novocherkassk Polytechnic Institute.

The permanent water intake structures of the Sayano-Shushenskaya GES are openings in the dam, submerged between the auxiliary capacity level of the reservoir and equipped with trashracks located in the bay window and with repair and rapid-acting operating locks. The design and geometrical configuration of the structures were subjected to thorough studies in the laboratory of the Leningrad Polytechnic Institute imeni M. I. Kalinin and the VNIIG imeni B. Ye. Vedeneyev with the participation of Lengidroproyekt specialists. As a result of the interdisciplinary scientific studies and design developments, an optimal design of the water intake of the hydroelectric power station is being developed. The water intake structures during the period of temporary operation of similar design were built according to the designs of the Lengidrostal' special design office and the Lengidroproyekt, with consideration of special investigations at the Leningrad Polytechnic Institute imeni M. I. Kalinin.

Interdisciplinary investigations of the water-conduit channel of the hydroturbine, conducted by the POT of the Leningrad Metals Plant, VNIIG imeni B. Ye. Vedeneyev and the Leningrad Polytechnic Institute imeni M. I. Kalinin with the active participation of Lengidroproyekt underlie the building, for guiding water to the turbine, of individual single-line conduits with a single-guide spiral chamber in place of the double-line conduits with a double-guide spiral chamber specified by the design assignment. Steel-reinforced concrete pressure conduits with a 7.5 m inside diameter have

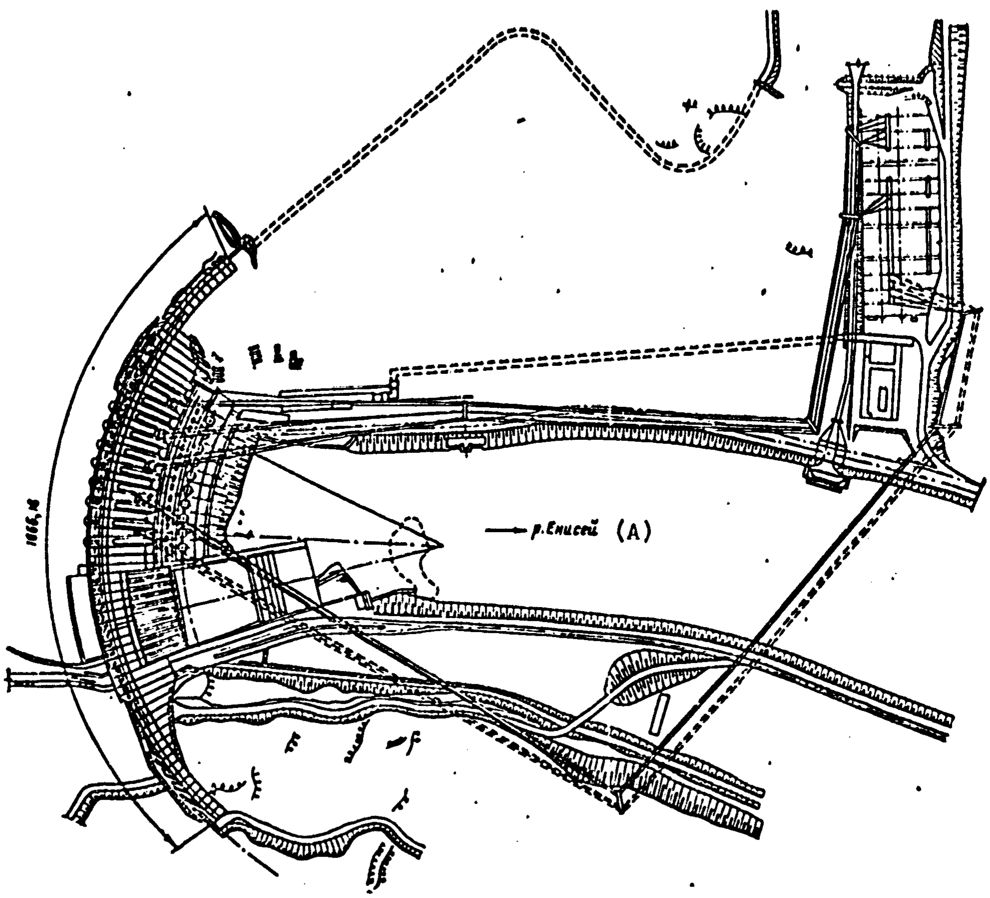

Fig. 1 Plan of hydroelectric power station

Key:
A. Yenisey River

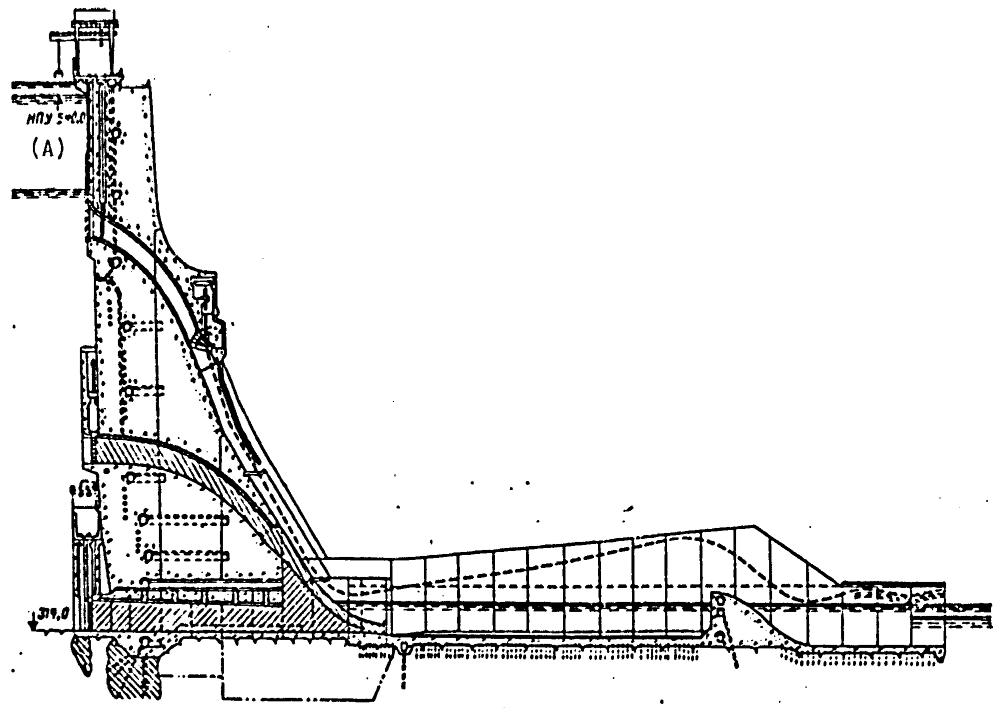

Fig. 2 Spillway part of dam

Key:

A. Normal backwater level

been calculated to stand an internal pressure up to 28.0 megapascals (280 kg/cm^2). They are situated on the downstream face of the dam, favorable for its static performance and ensuring the best conditions for conduit installation. Optimization of the conduit inside diameter was conducted on the basis energy-economic calculations of Lengidroproyekt and the Leningrad Polytechnic Institute imeni M. I. Kalinin under a special computer program drawn up by the latter.

New methodological developments of Lengidroproyekt in calculating the strength of steel-reinforced-concrete turbine conduits--on the basis of which studies were conducted at VNIIG imeni B. Ye. Vedeneyev, LTA imeni S. M. Kirov and Lengidroproyekt--permitted saving more than 17,500 tons of rolled sheet stock and reinforcement by taking account of the combined performance of the internal metal shell and reinforcement of the reinforced-concrete ring.

In the designing of the hydroelectric power station by Lengidroproyekt and by the LMZ and Elektrosila associations, a thorough investigation was made of problems of selecting the unit capacity of the hydroelectric installations over a wide range from 530,000 to 1.066 million kW, with a total GES installed capacity of 6.4 million kW. The accepted unit capacity of the hydroelectric installations of 640,000 kW (instead of 530,000 kW, under the initial design) with the option of forcing to 700,000-720,000 kW, was optimal according to technical and economic calculations. The installations of the Sayano-Shushenskaya GES represent a new step in domestic hydropower construction, following Krasnoyarskaya GES. Hydroturbines designed by the POT of LMZ, marked by high running speed, have a power rating 40 percent greater than hydroturbines of the Krasnoyarskaya GES, with a runner diameter of 6.77 m as compared with 7.5 m, at the latter GES. From interdisciplinary investigations, a high-efficiency flow-through channel was developed: in the overall dimensions of an installation block of 540,000 kW capacity (according to the design assignment), it can bring the turbine power to 650,000 kW, with the calculated head and to 735,000 kW, with a head of 212 m. The turbine design with replaceable runner that has been achieved provides for generating GES energy even at a head of 60 m (30 percent of the calculated value).

During studies at the POT of the LMZ with the involvement of the Scientific-Production Association of the TsKTI [Central Scientific Research, Planning and Design Boiler and Turbine Institute imeni I. I. Polzunov], LPI imeni M. I. Kalinin and VNIIG imeni B. Ye. Vedeneyev, a series of high-efficiency radial-axial runners were developed for heads of 170-230 m.

The turbine runners are built nondismountable; this makes them more reliable; they are delivered to the construction site by water from Leningrad over the Northern Sea Route and the Yenisey River.

Exceptional interest is drawn to the design of a spiral turbine chamber, built after joint experimental and theoretical developments at Lengidroproyekt, the POT of the LMZ, VNIIG imeni B. Ye. Vedeneyev, Leningrad Polytechnic Institute imeni M. I. Kalinin and the Scientific-Production Association of TsKTI imeni I. I. Polzunov for heads to 28.5 megapascals (285 m water column), built in the form of a steel-reinforced-concrete structure that is of one piece with the central part of the installation block.

The unique 720,000 kW hydroelectric generator, developed in the Leningrad Elektrosila Power Association imeni S. M. Kirov, in its main indicators has no equal anywhere in the world; its efficiency is as high as 98.3 percent. New electrotechnical, construction and insulation materials have developed and approved; a complex of new design solutions was developed for reducing the additional losses and local overheating in the active core of the hydroelectric generator; a double-row thrust bearing was developed for a load of 35 meganewtons (3600 tons) at high tip speeds; a unified system of water cooling of the stator and thyristor converters was designed and so on.

As the hydroelectric generators were designed, more than 150 basic research studies were carried out. A large cycle of full-scale investigations was conducted at the last two hydroelectric installations of the Krasnoyarskaya GES, which are in many features the prototype of the Sayanskiy installations. Besides investigators, designers and technologists of the Leningrad Elektrosila Energy Association, taking part in the interdisciplinary scientific research work associated with building the hydroelectric installations of the Sayano-Shushenskaya GES were scientists of the VNII energetiki [All-Union Scientific Research Institute of Power Engineering], VNIIElektromash, Leningrad Polytechnic Institute imeni M. I. Kalinin and so on. Noteworthy are the investigations on the technology of making a special copper shape for the stator of the generator made at the Krasnyy Vyborzhets Association and the Leningrad Polytechnic Institute imeni M. I. Kalinin, as well as studies of the Leningrad Steel-casting Plant in making nonmagnetic ventilation tie beams of the stator.

The relatively small dimensions of the hydroelectric installations of the Sayano-Shushenskaya GES predetermined the possibility of developing a compact installation block (the width of the Sayano-Shushenskaya GES block is 6.2 m smaller than at the Krasnoyarskaya GES), with minimum concrete volume. A solution to this problem became possible after strength and dynamic investigations of Lengidroproyekt, the VNIIG imeni B. Ye. Vedeneyev and the LPI imeni M. I. Kalinin.

Based on extensive scientific research and pilot-plant work, difficulties were overcome in building conductors and equipment in the 15.75 kv generator voltage circuit at the rated current of 28,500 A, capable of withstanding a shock short-circuit current of 450 kA. The solution put into effect is based on a profound scientific treatment of this problem by a number of organizations, first of all the LPI imeni M. I. Kalinin, with consideration of the potentialities of conductor-manufacturing plant. Based on the agreement of scientific and engineering cooperation, the Elektroapparat Association developed the world's first equipment generator set (KAG) for a voltage of 15.75 kV and current to 30 kA; it includes all equipment for generator voltage usually installed in the circuits of the main terminals separately.

A special scientific-engineering problem was the building of a 500 kV outdoor distribution system. The only area suitable for accommodating the ORU [outdoor distribution system] was approximately 1 km from the GES, in the Karlovka River valley, this river being a tributary of the Yenisey River. Siting a standard ORU could scarcely be conceived of in this narrow valley owing to the need of making large excavations. A new design had to be arrived at that would permit accommodating the ORU in the valley. Becoming involved in solving this problem were Lengidroproyekt, the Elektroapparat and Elektrokeramika associations, the NII postoyannogo toka [Scientific Research Institute of Direct Current] and LPI imeni M. I. Kalinin, along with the Velikiye Luki High-Voltage Equipment Plant. Arriving at the new design proceeded in three directions: developing a new layout with vertical suspension of busbars; narrowing the air insulation gaps by using radically new equipment for limiting lightning and switching surges, OPN-500 and OPNM-500; building and using new small-size high-voltage equipment: the VVBK-500 high-voltage breaker and the RGZ-500 disconnecting switch.

As a result of the integrated scientific research, pilot-plant and design studies, the 500 kV ORU was accommodated in an area 2.3 times smaller than the standard area; the ORU-500 of the Sayano-Shushenskaya GES is the world's smallest ORU of this voltage class. The design solutions adopted and put into effect and the newly designed and built high-voltage equipment can be used also in the future for power stations and electric power network construction.

Interdisciplinary studies of technological processes at hydroelectric power stations conducted with allowance for operating experience with the automated control systems of the Votkinskaya and Krasnoyarskaya GES made it possible to develop an automated industrial process control system at the Sayano-Shushenskaya GES with augmented reliability; it provides automatic control of GES operating regimes and monitoring of equipment and structure performance. Reliable contactless semiconductor equipment found applications in the automated control systems of the hydroelectric installations and signal indication systems.

As a result of the integrated scientific studies, a series of new relay protection devices were developed; they measure up to stiffer requirements of protecting the unique electrotechnical equipment. Solutions became possible to the problems of protection and automatic circuit breakers for the Sayano-Shushenskaya GES owing to the creative cooperation of Lengidroproyekt, VNIIElektromash, TsNIIKA [Central Scientific Research Institute of Complex Automation], the LPI imeni Kalinin, the VEI [All-Union Electrotechnical Institute] imeni V. I. Lenin, SibNIIE [Siberian Scientific Research Institute of Electrification], LZEIP, VNIIG imeni B. Ye. Vedeneyev, the Novosibirsk Electrotechnical Institute (NETI), the LMZ and Elektrosila associations, the Elektropul't Plant and the Scientific Research Institute of the Saransk Elektrovypryamitel' Plant.

Organizations taking part in designing and building the Sayano-Shushenskaya GES implemented the plan for erecting the hydropower station that provides for commissioning for temporary service of the first hydropower installation of the GES at a lowered head of 60 m, with the completion of 40 percent of the total volume of concrete work for the dam and with outlays not exceeding 40 percent of the total volume of capital investments for the hydropower with the subsequent forced start-up of the GES at the rated energy release. This solution made it possible to cut back by no less than 2 years the schedule for starting up the first GES installation and to place it in service in December 1978, to lower the level of immobilizing of capital investments and to generate an extra 24.4 billion kWh of cheap electric energy in the construction period. This solution required conducting a large number of investigations on admission of construction flows, on installing temporary GES water intakes and studying the stressed condition of the dam as it is being erected and the subsequent raising of the head during the period of temporary GES operation. The POT of the LMZ conducted interdisciplinary and design studies and built special replaceable runners that ensure the start-up of GES at low heads. The replaceable runners, after the required minimum head (120 m) has accumulated at the GES, are replaced with permanent runners without redesigning the hydroturbine insertion parts.

The Sayano-Shushenskaya GES is being constructed with the use of the most modern construction equipment for earth-rock and concrete work.

The adopted and in-effect scheme of working the foundation of the left-bank abutment of the dam, more than 600,000 m^3 in volume without the installation of intermediate adits made it possible to sharply accelerate operations and ensured the state of preservation of the rocky masses near the GES. The complex of design, scientific and experimental studies (including at the specially prepared proving ground) made it possible to project the optimal conditions for concrete preparation and placement that ensure the monolithic nature and water impermeability of the structure, and the necessary temperature conditions and development of intrablock mechanization.

For the fastest possible start-up of the GES, concrete plants and pit operations have been constructed for obtaining aggregates, designed for making a concrete mix to 2-2.2 million m^3 a year; construction is completing at a high-productivity enrichment department and thermal storehouses of aggregates.

The high intensity of concrete work is ensured by a complex of high-productivity machinery and specialized equipment. The concrete mix is transported from the concrete plant to the placement location by specially reequipped BelAZ-540 dump trucks. The concrete is supplied to the concreting blocks with 8 m^3 buckets and with the heaviest-duty modern concrete-laying KBGS-1000 cranes built at the plants of the USSR Ministry of Power and Electrification with the participation of the Leningrad Plant of Materials Handling Equipment imeni S. M. Kirov. The concrete mix is worked with a high-productivity manipulator, and the cement film is removed from the concrete surface with a cleaning machine. This machinery was designed and built by Sayano-Shushenskaya GES builders.

New types of multiple-use overhang falsework were mastered in the construction. Tests were conducted on mobile falsework for continuous concreting of the inclined spillway face.

The unique size of the structures, the high level of stresses in the arch-gravity dam and a number of other vital factors are responsible for the need to conduct a broad range of observations and investigations of the structures both during construction and during operation. Special-purpose control instrumentation is being placed in the structures of the hydroelectric power station and in their foundations for conducting full-scale observations of the overall deformations of the main structures, rocky foundation and banks and of their condition, the concrete temperature in the structures, stressed state, filtration in the body of the dam and its foundation, the state of cementation and drainage installations and many other characteristics; the emplaced control instrumentation provides operational monitoring of the reliability of the structure both during construction and during operation of the built structure.

During the adjustment work and in the start-up of the hydroelectric power installations, provision is made for conducting integrated tests and studies of the newest equipment, instruments and systems of protection and circuit-breaking with the involvement of the materially interested organizations and departments. The results of full-scale studies will supply the needed information about the state of the structures and equipment for their functioning and will furnish valuable material for further designing.

The Sayano-Shushenskaya GES is being built near the village of Shushenskaya--the place of V. I. Lenin's Siberian exile. This accounted for the memorial significance of the hydropower station, as a physical embodiment of Lenin's dream of Russia's electrification. The Sayano-Shushenskaya GES, by reflecting the latest advances in the scientific and engineering though of the Soviet hydropower engineers, is being constructed as an architectural-artistic monument to our age. Architects, artists, design engineers and equipment designers in creative cooperation are producing an expressive monumental artistic exterior to the hydropower station structures and its access roads and are solving at the level of modern requirements of engineering esthetics and engineering psychology all the basic and auxiliary equipment of the hydroelectric power station.

The socialist competition to shorten the construction schedules for the Sayano-Shushenskaya GES gotten underway on the initiative of the 28 Leningrad organizations and backed by the Krasnoyarsk organizations, with high construction quality maintained, made it possible on tighter schedules to resolve a wide range of the most challenging scientific-technical problems of designing structures, construction, development and manufacturing of unique equipment for this hydropower station, commissioning the first hydroelectric installation in 1978 and commissioning ahead of schedule the subsequent hydroelectric installations and the entire hydroelectric power station.

The necessary prerequisites have been provided for an additional national-economic benefit through the introduction of new innovative solutions, the advance (by two years) placing in service of the first hydroelectric installations and the additional generation of electric energy in the period of temporary operation valued at not less than 90 million rubles and a savings of more than 150,000 tons of cement and 25,000 tons of metal.

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ELECTRIC POWER AND POWER EQUIPMENT

LENINGRAD ORGANIZATIONS COLLABORATE IN BUILDING SAYANO-SHUSHENSKAYA GES

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 1, Jan 79 pp 4-8

[Article: "Effect of Creative Cooperation of Leningrad Organizations Participating in Building the Sayano-Shushenskaya GES"]

> [Text] "I have been told about the cooperation of the enterprises and organizations of Leningrad with the builders of the Sayano-Shushenskaya GES. The goal of this cooperation was approved by the Central Committee because it leads to shorter construction schedules for hydroelectric power stations. And the commitments of both Leningrad and Krasnoyarsk show a high quality of operations during the construction of this hydroelectric power station. The record has shown convincingly that it is precisely this approach of cooperating groups to meeting the most important national-economic challenges that is the most productive. The GES builders, in cooperation with the Leningraders, raised sharply the pace and quality of project construction." (From a conversation of comrade L. I. Brezhnev with members of the Krasnoyarsk kraykom, 1 Apr 78).

The Sayano-Shushenskaya GES is a unique hydrotechnical and energy project. The hydroelectric power station will become the center of the Sayanskiy Territorial Industrial Complex and will become a constituent part of the Lenin Memorial "Siberian Exile of V. I. Lenin" Complex. Building the Sayano-Shushenskaya GES demanded from the planners, builders, designers, scientists, industrial workers and artists an all-embracing creative approach to meeting this honorable challenge.

* The article was given to the editor by Yu. A. Grigor'yev, chairman of the coordinating council of Agreement 28 of Leningrad organizations in building the Sayano-Shushenskaya GES and director of the Leningrad division of the Gidroproyekt [All-Union Planning, Surveying and Scientific Research Institute imeni S. Ya. Zhuk].

For many years the Leningraders have been finding solutions to problems of designing large hydroelectric power structures and in designing and building the latest equipment for hydroelectric power stations at a level that outdoes the world level in originality of engineering conception, efficiency and quality. One example can be seen in the Krasnoyarskiy GES on the Yenisey River, equipped with 12 500,000-kW hydropower installations.

Leningrad project-planning and scientific research organizations have been assigned the completion of 95 percent of all work in exploration, investigation and designing of the Sayano-Shushenskaya GES. Three-fourths of all equipment for this hydroelectric power station are being developed, manufactured and installed by Leningrad production associations, plants and installation organizations.

A new form of socialist competition, approved by the CC CPSU and gaining wide familiarity as "Agreement 28"--from the number of Leningrad scientific research, project-planning institutes, associations and plants--equipment suppliers and installation organizations--agreement initiators, found wide acceptance among the working collectives of the country taking part in building this hydroelectric power station. The Leningrad initiative was supported by the builders of the Sayano-Shushenskaya GES and by working-people of Krasnoyarskiy Kray. Today more than 50 Leningrad, 43 Krasnoyarsk and upwards of 30 other organizations in the country have been caught up in the orbit of cooperation. The agreement of the Leningrad organizations has the following as its basis: at the early stages of development of the integrated draft of the most important national-economic project to bring to light trends in equipment advances and the possibilities of industry and construction and to coordinate in the long-term profile operational plans, by realizing the fast possible introduction of the latest achievements in science and technical in the industrial complex under construction.

Agreement participants chose as their slogan: "Technical Progress and Scientific Substantiation, Minimum Material Outlays and Effectiveness, Reliability and Long Service Life and High Level of Engineering Esthetics of Structures and Equipment of the Hydropower Project." "Agreement 28" embraces 13 scientific-technical problems in building the Sayano-Shushenskaya GES, including:

development of unique hydroelectric structures; high-head dam and hydroelectric power station equipped with 640,000-720,000 kW hydropower installations

designing and building a complex of hydropower equipment that outdoes in power rating, efficiency and reliability the best world performance records

designing and building the newest electrotechnical equipment

developing new systems of GES protection and automation, as well as an automated system of controlling technological processes of the Sayanskiy hydropower cascade ensuring high quality of generated energy and emergency-free operation of the GES integrated solutions to questions of architectural-artistic execution of the hydropower and engineering esthetics of equipment.

A coordinating plan was developed for solving these problems by the Leningrad organizations during a period of 5-7 years from exploratory scientific research and pilot-plant studies to the manufacture and installation of the newest equipment and the preparation of working drawings for hydropower project construction.

Based on the coordinating plan "Agreement 28" participants drew up a consolidated network schedule encompassing more than 3000 events during the period from the time the Yenisey River channel was closed off in 1975 to the commissioning of the first hydropower installation of the Sayano-Shushenskaya GES. In the development of the coordinating plan and the network schedule, a number of "blank spots" were uncovered as well as unsolved industrial engineering problems and ways of solving them were projected.

Posited as the basis of the coordinating plan was the start-up layout of the Sayano-Shushenskaya GES developed by the main "Agreement 28" participants jointly with the builders that makes it possible two years ahead of the projected schedule to place in service the first hydropower installation of the hydroelectric power station and to generate in the period of temporary operation of the GES more than 16 billion kWh of cheap electric energy and to realize an additional national-economic effect of not less than 44 million rubles. In essence the coordinating plan was a grass-roots plan.

The construction schedules and the manufacture of the newest equipment projected in the plan were examined by the USSR Ministry of Power and Electrification, Gosplan USSR and other all-union ministries and were taken into account in preparing a USSR Council of Ministers Resolution in 1976: "On Measures for Accelerating Construction and Commissioning of the Sayano-Shushenskaya GES on the Yenisey River."

A coordinating council is engaged in the practical work of coordinating the creative cooperation of Leningrad organizations, matching and interweaving of schedules determined by the socialist commitments of working collectives, in carrying out given developments and in monitoring joint commitments; included in the coordinating council are leading scientists, specialists, party, trade union and economic directors and representatives of the scientific and engineering community.

The council and its two sections--"Hydroelectric Power Station" and "Dam"--and the bureau of the coordinating council are operating under a unified plan set up for each year. By the plan the principal task of the year is determined and the energies of all competitors are directed first of all at its accomplishment. However, also under the eye of the council continually are other questions, reflected in the integrated network schedule.

At sessions of the coordinating council, held regularly not less often than twice a year, under discussion have been urgent questions of the course of scientific research on hydroelectric structures, the designing and building of hydropower and electrotechnical equipment and the preparation and carrying out of installation work in the GES and on solutions to architectural and esthetic problems.

Scientists, designers, project-planners and economic personnel have revised the schedules for individual stages of operations, at sections discussing technical questions and new aspects to solving scientific-technical problems.

Twice a year the end-results of the socialist competition are summed up at a session of the bureau with the participation of representatives from the industry-oriented trade union councils. The ranking Red Banner of Builders of the Sayano-Shushenskaya GES and the ranking prizes are handed over to the victor-collectives. The most outstanding workers are awarded Honorary Certificates.

Control over the carrying out of adopted socialist commitments and decisions of the coordinating council is exercised not only during the preparations for holding the sessions of the council, its bureau and its sections, but also on a day-to-day basis by the coordinating council secretary and the section representatives. Agreement participant-organizations not less than once every six months present to the coordinating council a report in established form about the solutions to scientific-technical problems as well as other reports: on completion of investigations and stages of projects, experimental and design developments, production tooling, testing and manufacture of equipment.

The coordinating council supports permanent direct ties with numerous organizations and enterprises in the country, with the coordinating council of Krasnoyarskiy Kray and with the leadership of Krasnoyarskgesstroy and several ministries.

In its work the coordinating council relies on vigorous work by the staffs or coordinating councils set up at the Leningrad Agreement-28 participant-organizations.

All activities by the coordinating council are on a voluntary basis. Moral incentives are determining in its work among the competition participants. In placing special significance on these incentives, two rallies of ranking workers--competition winners--were held. More than 4000 took part in these rallies. Success would be unthinkable apart from the day-by-day active attention to questions of creative cooperation among party organizations in enterprises, party raykomy, daily leadership of the Leningrad obkom and gorkom, Leningrad obkomy of trade unions of workers in power stations and machine building, as well as help from Krasnoyarsk organizations and--above all--the Krasnoyarsk kraykom.

During the socialist competition of Leningraders and builders of Sayano-Shushenskaya GES, one more side of the competition came to light--very vital in the cause of struggling for higher quality: a bilateral agreement between the brigades of workers, equipment makers and installers of the Sayano-Shushenskaya GES. Today five agreements like these are in effect.

Personal contacts of LMZ [Leningrad Machine Building Plant] workers with the builders during 1975-1978 made this form of competition particularly effective.

In 1977 and 1978 the Leningrad consolidated student detachment made its contribution to the creative cooperation of the working-people in the city on the Neva and the builders of the hydroelectric mammoth on the Yenisey, by doing construction and installation valued at 2.2 million rubles.

Under the coordinating council's plan, a scientific-technical conference--"Effectiveness of Scientific Research for the Sayano-Shushenskaya GES--was held in 1977 with the active participation of scientists and specialists from the Leningrad Polytechnic Institute imeni M. I. Kalinin, the VNII gidrotekhniki [All-Union Scientific Research Institute of Hydraulic Engineering] imeni B. Ye. Vedeneyev, Lengidroproyekt [Leningrad Branch of the All-Union State Planning Institute "Gidroenergoproyekt"] and the TsP NTO EiEP [Central Administration of the Scientific-Technical Society of Power Engineering and Electrification Industry].

At the conference 118 papers were presented by Agreement 28 participant-organizations and by Krasnoyarskgesstroy, the scientific-research sector of Gidroproyekt, the Mosgidrostal' special design office, Gidrospetsproyekt [State All-Union Trust for the Reinforcement of Foundations and Structures of Glavgidroenergostroy] and other organizations dealing with problems of hydropower engineering, hydroelectric structures, hydropower, hydromechanical and electrotechnical equipment, protection and automation and technology of construction and installation work. Conference participants analyzed and evaluated the results of scientific-research and pilot-plant work done during 1974-1977 for a detailed substantiation of solutions for the principal hydroelectric structures and equipment of this hydroelectric power station, examined questions of their introduction and outlined the most urgent tasks for the near-term future. As a result of the four-years' of productive work under the leadership of the Leningrad party organizations by workers, engineers and scientists of the city of Leningrad, 15 designations of the newest equipment were designed and built, surpassing in many parameters the world performance records.

Leningrad power machine building associations--Leningrad Metals Plant, Elektrosila Plant imeni S. M. Kirov and Izhorskiy Plant imeni A. A. Zhdanov--designed and built hydropower equipment surpassing the best world counterpart equipment in rated power, efficiency and specific material consumption. The following associations made their creative contribution to the designing and building of these unique hydropower installations: Krasnyy treugol'nik, Nevskiy zavod, Sevkabel', Krasnyy vyborzhets, Sever, Proletarskiy zavod, Plastpolimer, Stankostroitel'noye imeni Ya. M. Sverdlov, the plants Bol'shevik and Instrument and the institutes: Leningrad Polytechnic Institute imeni M. I. Kalinin, VNIIElektromash [All-Union Scientific Research Institute of the Technology of Electric Machinery and Equipment Manufacture], TsKTI [Central Scientific Research, Planning and Design Boiler and Turbine Institute] imeni I. I. Polzunov, VNII abrazivov [All-Union Scientific Research Institute of Abrasives and Grinding] and others.

The national-economic benefit from the unique hydropower installations will be 38 million rubles.

Transportation workers of the river and maritime fleet worked quite hard for the first hydroturbines to be delivered on time at the construction site from Leningrad to the city of Sayanogorsk.

Leningrad enterprises in the electrotechnical industry--the associations Elektroapparat and Elektrokeramika, in cooperation with scientists from the NII postoyannogo toka [Scientific Research Institute of Direct Current] and the LPI [Leningrad Polytechnic Institute] imeni M. I. Kalinin, and designers from Lengidroproyekt with several plants and associations of Leningrad participating designed and built the high-voltage, single-bay VVBK-500 circuit breaker, a radically new high-voltage unit--the OPN-500 overvoltage limiter and insulators for the RGZ-500 small disconnect switches. Use of these high-voltage units at the Sayano-Shushenskaya GES will save more than 3.2 million rubles.

Lengidroproyekt, in cooperation with scientists from the NII postoyannogo toka and the northwest branch of the Energoset'proyekt Institute, designed and built a 500 kV outdoor distribution system of new original design, employing new high-voltage units that permit reducing its area by 2.3 times compared with the model installation, boosting the reliability of power supply in the process.

Modern means of protection and circuit-breaking were developed; in conjunction with the automated industrial process control system of the Sayanskiy hydropower cascade, they ensure high reliability and quality of electric energy generated and operating convenience. Participating in the designing and building of the new protection and circuit breakers were Lengidroproyekt, the Elektropul't Plant, the Leningrad Metals Plant Association, the Elektrosila Association, VNIIElektromash and VNII tekhnicheskoy estetiki [All-Union Scientific Research Institute of Engineering Esthetics].

Lengidroproyekt, VNIIG [All-Union Scientific Research Institute of Hydraulic Engineering] imeni B. Ye Vedeneyev, the Lengidrostal' special design office and Energoset'proyekt [All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks] proposed a solution that, allowing for the actual course of construction, provides the conditions for starting up the first hydropower installation on the schedules in the voluntary plan of workers in Leningrad and at the Sayano-Shushenskaya GES in 1978.

Incorporating in the working plans of the hydropower installations at the Sayano-Shushenskaya hydropower station the results of scientific studies already permitted reducing capital expenditures in the principal installations of the hydropower station by 40 million rubles and will make it possible to lower still further capital outlays for the volume of work in the Tenth Five-Year Plan by not less than 7 million rubles.

A cement savings of 9000 tons (in the working drawings) was achieved in the volume of concrete used in the start-up complex, and a savings of 5000 tons of reinforcement steel and rolled steel stock.

The scientific investigations and design developments completed by Agreement 28 participants during a period of four years confirmed the real possibility of achieving through their adoption in joint socialist commitments of a national-economic benefit in the amount of more than 90 million rubles. This benefit will be achieved over an eight-year period.

The national-economic benefit from the ahead-of-schedule placing in service the first installation with a replaceable turbine runner will be 8 million rubles. During studies on solving the scientific-engineering problems at Sayano-Shushenskaya GES more than 150 inventions were developed and applied.

Experience gained in scientific investigations, designing Sayano-Shushenskaya GES structures and in the manufacture of the unique equipment will strongly affect all power and network construction in the past several years and will also economize on sizable capital investments.

Start-up of the first hydropower installation is the culmination of an admittedly large, but still just the first stage of work of the coordinating council of the Leningrad Agreement 28 participant-organizations and the Krasnoyarskgesstroy builders.

Conditions must be provided for the forced attainment by the Sayano-Shushenskaya GES of the design energy release. For a successful solution to this problem there is a need to complete the designing and building of a 640-720 MW hydroturbine and hydrogenerator and to make a number of electrotechnical units and mechanical equipment. Ahead lies the final revisions of prototypes of the newest equipment and bringing them up to design rating; ensuring the delivery of the full complex of equipment for nine hydropower installations --all complete and as per the necessary schedules. Working drawings must be prepared for the Sayano-Shushenskaya GES dam for 5 million m^3 of concrete, thereby ensuring the introduction of innovative solutions for achieving cement and reinforcement steel savings.

Joint commitments of Krasnoyarsk builders erecting the Sayano-Shushenskaya GES and Leningrad designers, scientists and equipment builders broke ground for new possibilities of active influence of party organizations and working-people of all collectives in meeting complex state challenges. This approach enables each worker, engineer and specialist not only in construction and installation areas in the Sayany Mountains, but also at the plant where the equipment is being made, in the laboratories where studies go on and at the drawing boards where the structure is designed and assemblies and parts of future installations are drawn, to understand clearly their specific tasks in the overall effort and to distinctly conceive of their contribution to building the Sayano-Shushenskaya GES.

Agreement 28 has enriched science and practice with a new method of meeting large national-economic challenges; it has become a new form of interindustrial organization of the integrated development and designing and building of large projects and must be placed as the basis of further work in the advancement of hydropower engineering in the USSR.

The Lengidroproyekt collective has been assigned the designing of hydroelectric power stations on the Yenisey. Leningraders must made a heavy contribution to designing and building equipment for these GES of domestic power engineering and in meeting the most complex challenges in scientific research, including questions of environmental protection and rational development of fisheries and forests and water transportation.

In his report at the ceremonial session in the city of Leningrad dedicated to the 60th anniversary of the Great October Socialist Revolution, Politburo member, First Secretary of the Leningrad obkom, comrade G. V. Romanov, in appraising the initiatives of the Leningraders, said: "Deepening of the bonds of science with manufacturing is fostered by the wide acceptance of the initiative of 28 Leningrad collectives, approved by the Party Central Committee, in the integrated solution of problems associated with the building of the world record-breaking Sayano-Shushenskaya GES. Today hundreds of scientific and production associations of the city, in meeting their agreements on creative cooperation, are taking part in building the Baykal-Amur Main Trunkline and the Kama Automotive Plant, the Ust'-Ilimskiy and Sayanskiy territorial-production complexes, in advancing nuclear power engineering and tractor manufacturing and in meeting many other national-economic challenges. It is appropriate to note that the plans and equipment for the leading new construction sites have been prepared ahead of schedule and at the very highest technical level."

A high rating for the Leningraders' and Krasnoyarskites' contribution to the construction of the Sayano-Shushenskaya GES, given by the General Secretary of the CC CPSU, Chairman of the Presidium of the USSR Supreme Soviet, comrade L. I. Brezhnev, during a conversation with Krasnoyarsk kraykom members in April 1978, rouses the collectives of Leningrad enterprises and Sayanskiye builders with renewed energy to labor over fulfilling their socialist commitments for the fastest possible building of the Sayano-Shushenskaya GES.

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ELECTRIC POWER AND POWER EQUIPMENT

CURRENT TECHNICAL-ECONOMIC SUBSTANTIATION FOR HYDROPOWER PROJECTS

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 1, Jan 79 pp 40-41

[Article: "In the Scientific-Technical Council"]

[Text] Technical and economic substantiation of the Leningrad Pumped-Storage Hydroelectric Power Station. The Leningrad Pumped-Storage Hydroelectric Power Station, installed capacity 1300 MW, is projected for satisfying load peaks and filling the night troughs of the energy load schedules, for carrying load and emergency reserves and for operating in the mode of synchronous compensator in the Lenenergo [Leningrad Regional Administration of Power System Management] system, part of the Unified Power System of the Northwest.

Included in the structures of the pumped-storage hydroelectric power station are the elevated storage reservoir with a useful capacity of 32 million m^3, built in embankment dams with a total length of 9135 m, of sandy soil with loam shield; water intake of the depth type; delivery steel-reinforced-concrete conduits 7 m in diameter and 410 m in length; the pumped-storage power station building, to house eight radial-axial turbines with a 6.3 m runner diameter and a unit capacity of 163 MW; a two-way canal 168 m long and a tailwater supply reservoir on the Shapse River with homogeneous sand dam with a maximum height of 30 m.

The Scientific-Technical Council approved the technical and economic substantiation of the Leningrad Pumped-Storage Hydroelectric Power Station and recommended at the next design stage an examination of the possibility and technical soundness of augmenting the per-unit capacity of the installation with a conversion to 7.5 m diameter turbines and a reduction in the number of installations to six; it was resolved to additionally examine the question of the selection and substantiation of the voltage for adding the pumped-storage power station to the power system and to revise the fuel and regime effect in the power system determining the ultimate effectiveness of the pumped-storage power station.

Energy-economic calculations in the technical and economic substantiation showed that the Leningrad Pumped-Storage Hydroelectric Power Station, compared with the replaced energy sources, is an effective object of first-priority construction; it is best to start building it in 1980.

Scheme for siting the GES-GAES [pumped-storage hydroelectric power station] in the European part of the USSR. The scientific-technical council examined the scheme for siting GES-GAES in the European part of the USSR, developed by the Gidroproyekt Institute imeni S. Ya. Zhuk; this scheme makes it possible to determine the composition of hydroelectric power stations and pumped-storage hydroelectric power stations, recommended for construction and commissioning before 1990, as well as a list of projects whose construction is projected for the 1991-2000 period.

The greater strain on the fuel and energy balance of the European regions of the country and the expansion of energy intertie systems mainly through the construction of large nuclear power and steam-electric power stations with limited flexibility of equipment determine the necessity for the maximum use of hydropower resources in these regions, and also for constructing GAES with their operation in the peak and semipeak zones of the load chart.

The work in question revealed the need for constructing and commissioning before 1990 hydroelectric power stations in the European part of the country alone with a total capacity of 3.6 million kW, generating 8.84 million kWh of electric energy and no less than ten GAES with a total capacity of 10-12 million kW. Besides the Zagorskaya GAES under construction, there is made provision for construction of the Kayshyadorskaya GAES, the Yuzhno-Ukrainskiy Power Complex, the Leningrad, Dnestrovskaya and Tereblinskaya GAES, for which technical and economic substantiations have been drawn up, as well as GAES in the Center (Rzhevskaya), in the Urals (Ponyshskaya), in the Northern Caucasus and in the South, for which technical and economic substantiations need to be drawn up in 1979-1980.

Moreover, it is recognized as necessary to compile in 1979-1982 the technical and economic substantiations for GAES to operate in the semipeak zone, for the following semipeak GAES: Pana-Yarvinskaya in the Intertie Power System of the Northwest, the Zhigulevskaya in the Intertie Power System of the Center and the Kanevskaya in the Intertie Power System of the South, as well as a first-priority semipeak GAES in Armenia and a GAES for the Northern Caucasus regions. Most promising for the Northern Caucasus are the Stavropol'skaya and Nevinnomysskaya GAES, as well as the Vysokogornaya GES-GAES at the Terek River and the Khamyshkinskaya GES-GAES on the Belaya River. The mutual effectiveness of the GES and the GAES of Georgia has been recognized as necessary to be examined in the development of the technical and economic substantiation for the Armenian GAES.

Looking at the difficulties with discovering the sites for placing the GAES, the Scientific-Technical Council recommended conducting scientific research on designing and building high-head GAES with subterranean reservoirs, as well as design work on building power complexes as part of nuclear and pumped-storage hydroelectric power stations.

Use scheme of the Kolyma River. The scheme provides for use of the upstream and downstream of the Kolyma River for an extent of 1000 km and a drop of 440 m by constructing along this stretch of the river, including the Kolymskaya GES underway, a cascade of five hydropower stations.

As the first-priority project after the Kolymskaya GES the lower-lying stage is recommended--the Ust'-Srednekanskaya GES with a reservoir with a useful capacity of about 8 km^3; it is characterized by the most favorable technical and economic indicators and the best transportation ties. The final parameters of the Ust'-Srednekanskaya GES must be established with the development of the technical and economic substantiation that takes account of the completion of special studies determining the effect of flow regulation on navigation conditions on the Kolyma River.

Construction of hydropower stations on the Kolyma River is projected by the construction collective of Kolymagesstroy with partial use of existing auxiliary enterprises and transportation ties; this determines the usefulness of the sequential construction of the cascade stages. It is sound to start in on developing the technical and economic substantiation for the Ust'-Srednekanskaya GES in 1979. Projected as the third hydropower station on the Kolyma River is the Verkhne-Kolymskaya GES with a multiannual flow-regulating reservoir with a useful capacity of 8.6 km^3, significantly increasing the generation of electric energy by the Kolymskaya and Ust'-Srednekanskaya GES.

Completing the mastery of the Kolyma River's hydropower resources is provided for in the scheme for constructing the two lowest stages of the cascade--the Ust'-Sugoyskaya and the Ust'-Korkodonskaya GES.

Adopted in the scheme is the construction of hydropower stations with dams made of local materials and passage of spring floods during the construction period over the incomplete dam and with the arrangement of hydropower stations that corresponds most fully to the natural conditions of the region.

Technical and economic substantiation of the Khudoni GES. The in-line section of the Khudoni GES on the Inguri River in the Georgian SSR was laid mainly of rocks, The thickness of the alluvial deposits in the channel with a filtration coefficient up to 100 m/day reaches 15 m., Located on the left-bank slope (above 660 m elevation) are loose deposits; they do much to complicate the erection of a dam given a seismicity of 8 scale divisions.

From a comparison of variants in the project plans, a 700 m elevation was adopted for the NPU [normal backwater level] and a Khudoni GES installed capacity of 700 MW in three installations generating 1800 million kWh of electric energy. A reservoir with a useful capacity of 220 million m^3 is under construction with an available capacity of 55 m, a guaranteed capacity of 65 MW and with allowance for the effect on the lower-lying GES of the cascade--133 MW.

The project plans provide for the hydropower station to be laid out with arch and rock-earth dams. The Scientific-Technical Council recommended that for further design planning the adoption of a layout of Khudoni GES structures with a 196.5-m high arch dam with open station building and a nonhead diversion tunnel. When the variants in the project plan cost nearly the same, the concrete arch dam corresponds most closely to the natural conditions of the region and the experience of the construction collective finishing the erection of the Ingurskaya dam and permits fuller use of the base of auxiliary enterprises and existing construction machinery.

Also approved was securing crushed aggregates for concrete from local quarries; this permits a large reduction in the haulage volume and lowers the required number of transportation units.

Considering the complex topographic conditions at the construction site and the housing stock in the Ingurskaya GES settlements, the "duty shift" construction method was adopted in the project plans, providing for placement of more than 3000 workers in these settlements.

The construction schedule for the hydropower complex of the Khudoni GES is 7 years, including 2 years for the preparatory period. Start-up of the first installations is set for the sixth construction year.

The technical and economic substantiation for the Khudoni GES examines a variant with a GES-GAES that has a total installed capacity of 2.14 million kW, with the building of the tailwater reservoir 7 km from the dam and the additional placement of reversible installations. Comparing this variant with the gas-turbine installation in the Intertie Power System of the South revealed the low effectiveness of the GAES.

Technical and economic substantiation of Yelandinskaya GES. The Yelandinskaya GES is a first-priority project in hydropower construction on the Katun' River, scheduled in a scheme: a cascade of six hydropower stations totaling 3730 MW in power, with a mean-annual generation of 18 billion kWh of electric energy.

The installed capacity of the Yelandinskaya GES in the project plans was set at 1350 MW; electric energy generation--5.1 billion kWh/year in isolated operation and 5.7 billion kWh/year in a cascade with the headwater flow-regulating Argutskiy hydropower station.

The Yelandinskaya GES will operate as part of the Intertie Power System of Central Siberia, joined by an 1150 kV line to the power systems of northern Kazakhstan and the Urals.

Under the recommended variant, included with the hydropower station structures are a rock-earth dam 165 m high and with a crest length of 860 m, formed of gravel with a gently pitched core of sandy-loam and with transition zones that have a two-tier cementation curtain at the base 60 m in depth, spillway structures on the right bank consisting of two 15 m diameter tunnels and a station complex sited on the left bank.

The Yelandinskaya GES reservoir, with a useful capacity of 2.36 km^3, is located in a sparsely populated place and cannot hurt agriculture very much.

Constructing the Yelandinskaya GES is important in many ways and permits increasing the winter river flows and thereby improving the sanitary condition of the Upper Ob' River near the city and large population centers, as well as reducing the flooding periods of the Ob' floodplain and release about 9000 hectares for agricultural uses.

The Scientific-Technical Council approved the main positions taken in the technical and economic substantiation of the Yelandinskaya GES and recommended for the next design stage an examination of the possibility of increasing the supporting level by 20 m aimed at the fuller regulation of Katun' River flow and a comparison of radial-axial with oblique turbines. Construction of the Yelandinskaya GES is recommended to start in 1980.

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FUELS AND RELATED EQUIPMENT

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GEOLOGICAL STRUCTURE OF ORENBURG REGION DISCUSSED

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 5, May 79 pp 16-22

[Article by G. V. Fomina, S. P. Makarova, Ye. I. Korotkova, N. G. Osipenko, N. A. Sergeyeva, V. S. Fomin and A. I. Shcherbakova (YuUO All-Union Petroleum Scientific Research Institute of Geological Exploration: "Characteristics of the Geological Structure of Sol'-Iletskiy Rayon of Orenburgskaya Oblast in the Light of New Data From Drilling and Seismic Prospecting"]

[Text] In the last few years the Orenburg TGU has been doing a considerable amount of exploratory prospecting work in Sol'-Iletskiy Rayon, where gas deposits have been discovered in the carbonates of the Lower Permian (Berdyanskoye, Kopanskoye and Komarovskoye deposits) stage and an oil deposit in the Bashkir stage at the Kopanskoye uplift.

An analysis of the materials of exploratory-prospecting drilling and the data from seismic prospecting, as well as a study of the microfauna made at the YuUo VNIGNI [All-Union Petroleum Scientific Research Institute of Geological Exploration] under the supervision of V. A. Goroshkova and G. D. Kireyeva, made it possible to ascertain the basic features of the geological formation of Sol'-Iletskiy Rayon and to establish the stratigraphic nonconformities in the Carboniferous and Lower Permian deposits and the bioherm structures of the Asselar age.

The territory under discussion occupies an advantageous structural position, being located within the limits of the Sol'-Iletskiy anticline, confined to the area of the chain of the Cis-Ural foredeep and the Caspian syneclise (Fig. 1). This caused its great tectonic activity throughout the Paleozoic era, as the result of which structural areas of the second order and flexurelike folds of the strata were formed.

In the thick Lower Paleozoic strata of the sedimentary cover there is no Devonian rock, which has been repeatedly pointed out by researchers [2, 4]. Stratigraphic nonconformities in the Middle-Upper Carboniferous and Lower Permian deposits have recently been discovered, in which, as compared with the earlier studied profiles of the central part of the oblast, one often encounters intercalations of silicified and spicular limestone and silicytes, and the addition of argillaceous and sand-aleurite material is increased. Intercalations of cinereous tufa were recorded for the first time in the Vereian horizon.

The terrigenous rocks of the Ordovician period, the thickness of which was revealed to be 690 meters at the Orenburg arch and the Krasnoyarsk area, are the most ancient here. The terrigenous-carbonaceous mass of the Famennian or carbonaceous Tournasian stages lie above. Outside the limits of these structures, the most ancient deposits (Tournasian stage, Chernyshinskiy superhorizon, thickness 67 meters) are extended to the Orenburg drill hole 101 in the western part of the Cis-Ural foredeep (see Fig. 1). Above them lie formations of the Visean stage, consisting of the Malinovskiy superhorizon, the Bobrikovskiy and Tul'skiy horizons, the Okskiy superhorizon and the Serpukhovskiy stage, with a total thickness fo 416 meters.* The upper parts of the Lower Carboniferous complex were also revealed by drill holes 159 and 149 at the Kammenoye uplift and drill hole 200 at the Mertvosol'skoye uplift. The cross section consists primarily of gray, dark gray, organogenic-detrital, argillaceous and pyritized limestones, in sections silicified with intercalations of secondary dolomites and sulfates.

The deposits of the Bashkir stage are developed everywhere, but to the full extent only at the Orenburg arch and the Chernigovoye and Kammenoye uplifts. Only a low substage, represented by light gray, almost white, primarily crinoidal-Foraminifera-algal limestones and oolitic, extremely porous intercalations, was established on the rest of the territory. The upper part of it is not in the cross section of drill hole 200 of the Kamennoye uplift, in which the presence of only the Krasnopolyanskiy horizon with a thickness of 22 meters was proven faunistically (Fig. 2).

The Vereian horizon is noted everywhere. It is formed by gray, dark gray Foraminifera-bryozoan-crinoidal limestones, and more often by spicular-crinoidal limestones, and to a varying degree by silicified, argillaceous, pyritized, bituminized (OV up to 10%) limestones, including authigenic glauconite and phosphates, with thin intercalations (up to 3-4 cm) of argillites, fuel shales, ash tufa and aleuritic sandstones. The total thickness of the rocks reaches 40 meters.

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* By decision of the plenum of the Interdepartmental Stratigraphic Committee (November 1974), the Namurian stage was excluded from the stratigraphic scale. Its upper part (the Krasnopolyanskiy horizon) was included in the Bashkir stage, and the lower (Protvinskiy horizon)--in the newly formed Serpukhovskiy stage.

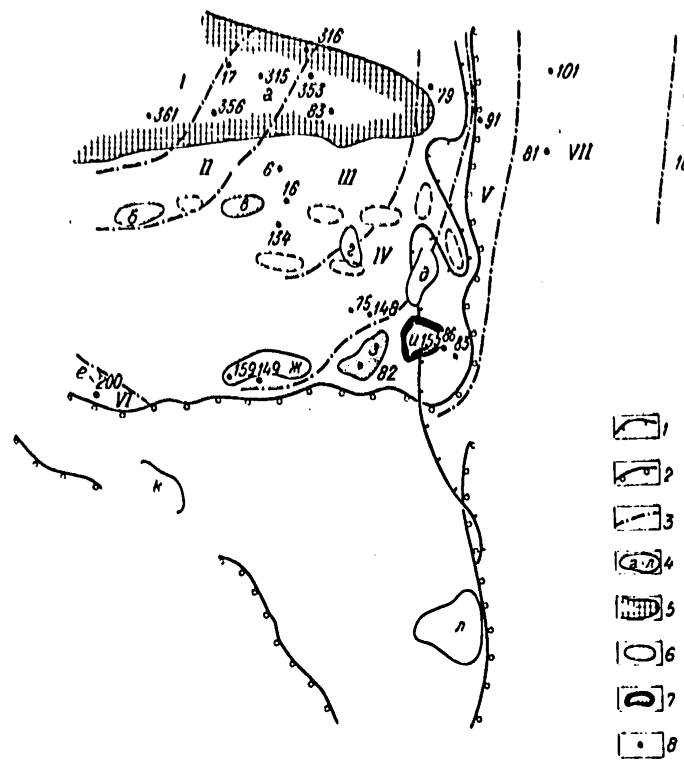

Figure 1. Tectonic Diagram of Sol'-Iletskiy Rayon

1--gravitation scarp; 2--flexures along subsalt Lower Permian deposits; 3--boundaries of zones of stratigraphic completeness of cross section; 4--local uplifts: a--Orenburg arch, b--Chernigovskoye, c--Komarovskoye, d--Severo-Berdyanskoye, e--Severo-Kopanskoye, f--Martvosol'skoye, g--Kamennoye, h--Berdyanskoye, i--Kopanskoye, j--Sol'-Iletskoye, k--Nagumanovskoye deposits: 5--gas condensate; 6--gas; 7--gas-oil; 8--wells: zones of nonconformity: I--of summits of Podol'skiy horizon at Kashiran, II--of summits of Podol'skiy horizon at lower part of Kashiran, III--upper part of Myachkovskiy horizon at Vereian, IV--Kasimovskiy stage at Vereian horizon, V--Assel'skiy stage at Vereian horizon, VI--Myachkoviy horizon at Krasnopolyanskiy, VII--Artinskiy stage at Lower Bashkir substage, VIII--Sakmarian stage at Lower Bashkir substage

The superposed formations of the Middle and Upper Carboniferous period are developed in sections. In the east of the region belonging to the Cis-Ural foredeep, they have been completely eroded. Deposits of the Bashkir stage here at Orenburg drill holes 101, 102, 108 and others are covered by Lower Permian rock. At the Kamennoye uplift (drill holes 149, 159) with erosion at the formations of the Vereian horizon occur faunistically characterized rocks of the Upper Carboniferous period, at the Kopanskoye (drill hole 155) and east of the Orenburg arch (drill hole 91)--of the Assel'skiy stage, and at the Krasnoyarsk drill hole 16--of the Myachkovskiy horizon.

At all the cross sections studied the rock mass of the Upper Carboniferous period was represented by shoal limestones, gray, rarely dark gray, semi-detrital, primarily algal-Foraminifera, bryozoan-crinoidal and algal, in some sections oolitic. In the lowermost strata there appear millimetric and centrimetric intercalations of dolomite-limestone marls, spicular silicytes and spicular and microgranular limestones.

The presence of these intercalations was also established in deposits of the Kashiran and Myachkovskiy horizons in the eastern part of the Orenburg arch (drill holes 315, 316, 353) among organogenic-detrital, mainly bryozoan-crinoidal and fusulinid limestones.

The carbonaceous Lower Permian rocks included in the Assel'skiy, Sakmarian and Artinskiy stages are inconsistent in thickness and are distinguished by lithologic-facies characteristics. Along the western rim of the Cis-Ural foredeep, a zone with increased thickness of these rocks (400-800 meters), 20 kilometers wide, was recorded. It includes the Kopanskoye, Berdyanskoye and Kamennoye uplifts and the region located to the north. Within its limits there is a uniform increase in the thickness of all three stages, but to the west it decreases to 250 meters (drill hole 200), and in some sections to the east (drill holes 81, 101)--to 8-20 meters.

In the zone with great depths in the Assel'skiy stage limestones that are light gray to white, porous and generally organogenic-detrital, crinoidal, crinoidal-fusulinid and algalike have developed. The organogenic structures consist of limestones and secondary dolomites. The limestones are white, massive and bryozoan-algal, generally tubifacient, fusulinid in some intercalations (drill holes 75, 82, 148). The Sakmarian-Artinskoye deposits are represented by limestones that are pseudo-endotyric and by fusulinid, coral and crinoidal intercalations. In the eastern cross sections of this zone (drill hole 155), silication and intercalations of spicular limestones are noted.

In the west of the territory, where the total thickness of the Lower Permian carbonaceous rocks is reduced, limestones that are light gray, organogenic-detrital and biomorphic (fusulinid), in sections detrital, have developed in the Assel'skiy stage. They are covered by gray, dark gray, clustered, lumpy-clustered limestones, with intercalations of pseudo-endotyric, coral and crinoidal varieties of the Sakmarian-Artinskian age.

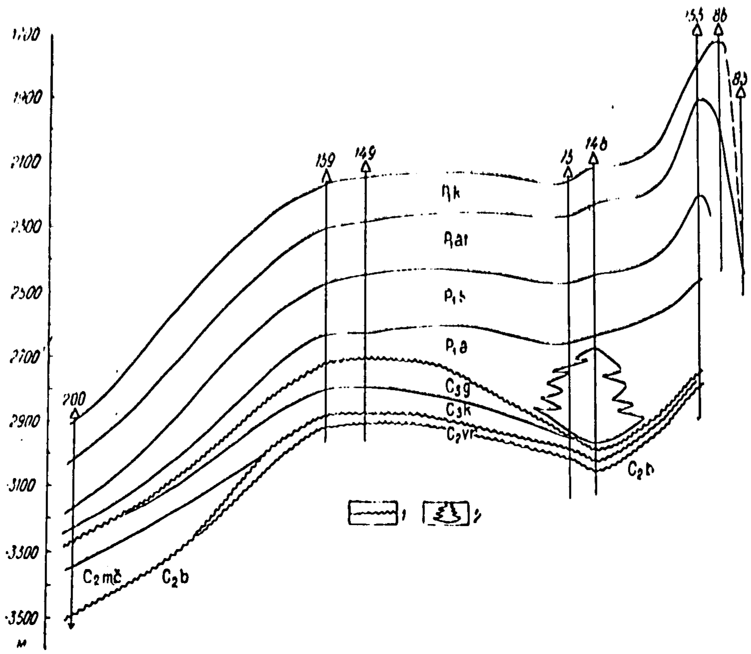

Figure 2. Geological Profile Between Drill Hole 200, Kamennaya, and Drill Hole 83, Berdyanskaya.

1--Stratigraphic nonconformity; 2--biohermic structure

The Lower Permian subsalt deposits of the Cis-Ural foredeep differ from the single-age formations of the Sol'-Iletskiy shelf in the structure and completeness of the cross section. Along the flexure of the western rim of the depression (drill hole 91, Orenburg; drill hole 83, Berdyanskaya), they are represented by relatively deep-sea formations that cover the Vereian horizon (drill hole 91). These are gray, dark gray microgranular limestones in the lower part, with intercalations of dolomites and marls 210 meters thick. The upper part of the Assel'skiy stage (30 meters) is formed by light gray, gray, organogenic-detrital, bryozoan-crinoidal and biohermic limestones. The overall thickness of the stage reaches 60 meters.

Somewhat to the east (Orenburg drill holes 101, 81), dolomites, marls, argillites and dark gray, often bituminous limestones have developed, pyritized to a varying degree, with a thickness of 8-20 meters, which cover the deposits of the Bashkir stage. At the summits of the cross section (drill hole 81), in a carbonaceous breccia (0.7 meters), an Assel'sko-Artinskian complex of Foraminifera was discovered.

At the more easterly drill holes (102, 108), the cross section consists of relatively thick terrigenous-carbonaceous flyschoidal formations. These are argillites and aleurites, with intercalations of sandstones, and in the lower part--organogenic-detrital, crinoidal-bryozoan-fusulinid limestones, with detritus of carbonaceous rocks, including redeposited Foraminifera of the Bashkir, Late Carboniferous and Assel'skiy age. The deposits of the Artinskian (drill hole 102), Artinskian and Sakmarian stages (drill hole 108), with a thickness of 200-460 meters, occur with erosion in the rocks of the Bashkir stage.

The superposed rocks of the Philippovskiy horizon of the Kungurian stage in the large western part of the region consist of anhydrites with intercalations of carbonaceous rocks 100-125 meters thick. The exception may be the brow of the flexure of the western rim of the Cis-Ural foredeep (see Fig. 2) within the limits of which there is assumed to be an increase in both the overall thickness and the thickness of the carbonaceous rocks (data from the logging of drill hole 86), by analogy with the Tashlinskiy region, with possible development of oncolytic limestones.

Apparently, within the limits of the region being studied, at the end of the Carboniferous and beginning of the Permian periods, there were repeated discontinuities in the deposit accumulations, with erosion of the larger part of the rocks formed earlier. While in the west of the territory only individual subdivisions of the Middle and Upper Carboniferous period are absent, in the east--the larger part of the cross section of the Lower Permian period is also missing. The amplitude of the discontinuity gradually and regularly increases from west to east and from north to south. The amplitude of the maximum discontinuity (from the Lower Bashkir rocks to the Lower Permian inclusive) is at least 900 meters.

In addition, small erosions were noted at the boundary of the Lower and Middle Carboniferous, Bashkir and Moskovskiy stages, the Upper Carboniferous and Lower Permian stages and between the substages of the Bashkir and the Moskovskiy stages and the Lower Permian stages. The presence of stratigraphic nonconformities was substantiated by the fauna of the Foraminifera. For example, at the Komarovskaya drill hole 134, in the bottom of the Assel'skiy deposits, in the detrital limestones, along with the Assel'skiy fusulinida, redeposited Late Carboniferous fusulinida are also present. At the Orenburg arch (drill holes 315, 356, 361), redeposited fauna of the Foraminifera of the Kashir-Vereian age were discovered in the rocks of the Myachkoviy horizon.

Therefore, the territory under discussion, in the pre-Assel'skiy and the Artinskian age, was the declivity of a large positive structure, the anticlinal part of which was apparently located within the Kiinskiy uplift [3]. This positive structure coincides with the eastern part of the Yaikskiy anticline [1]. The appearance in the interval from the Vereian horizon to the Artinskian stage inclusive of intercalations of spicular limestones, silicytes, clayiness, bitumen impregnation and, in sections, of limestones with Radiolaria (drill hole 91, Orenburg, drill hole 83, Berdyansk) attests to the relatively deep-sea or stagnant conditions of the sediment accumulation.

The results from processing the materials from the drilling are in complete accord with the data from geophysical studies. The Chernigovsko-Komarovskaya and Kamenno-Berdyanskaya zones, traced for a distance of 20-25 kilometers, with the amplitude of the northern side along the subsalt Lower Permian deposits from 100 to 300 meters, and complicated by the Chernigovskoye, Komarovskoye, Kamennoye, Berdyanskoye and Kopanskoye uplifts were established south of the Orenburg arch by seismic prospecting (I. Ya. Istomina et al., 1977; B. G. Chivilev et al., 1975) and by drilling. One other zone is outlined between them, and seismic prospecting (I. Ya. Istomina et al., 1978) revealed that the Severo-Berdyanskaya and Severo-Kopanskaya structures were included in them. The Chernigovsko-Komarovskaya zone apparently extends farther to the east. Since within the limits of the Kamenno-Berdyanskaya zone the amplitude of the local structure increases in the eastern direction, it may be assumed that in the eastern part of the Chernigovsko-Komarovskaya zone, the folds will also have considerably more amplitude than the Chernigovskaya and Komarovskaya zones. The local uplifts in the eastern part of these zones at the same time form a belt with a submeridional course, including the Kopanskoye, Severo-Kopanskoye and more northerly uplifts. They are precisely the ones that should have the greatest amplitude.

The overall dip of the strata toward the Cis-Ural foredeep and the Caspian syneclise is made more complicated by the flexures, established mainly by seismic prospecting. Only in the sections of the eastern Orenburg arch and the Kopanskiy uplift was the flexure confirmed by drilling. The main flexure of the sublatitudinal course passes directly south of the Kamenno-Berdyanskaya zone, and on the present-day structural plane of subsalt deposits is the northern boundary of the Caspian syneclise. It is traced along all the reflecting horizons comparable with the roof of the Artinskian and Bashkir stages, the Bobrikovskiy horizon and the Lower Paleozoic formations, and is of tectonic origin. The drop of the strata at its adjacent side reaches 10°, and the amplitude--over 1 kilometer. To the east it merges with the flexure of the western rim of the Cis-Ural foredeep, which has a submeridional course and an amplitude along the Lower Permian subsalt deposits of about 800 meters.

One more flexure of the northwest course (I. Ya. Istomina et al., 1976; L. A. Blagosmyslova et al., 1977) was established in the southwest of the territory studied recently by seismic prospecting. Together with the flexure of the western rim of the Cis-Ural foredeep, it separates the southern block of the Sol'-Iletskiy anticline, which on the current structural plane of the subsalt and Middle Carboniferous deposits is considerably (over 1 kilometer) depressed with respect to the northern regions. At the same time, the sinking apparently occurred at a later time, and in the Lower Permian period it was a unified whole with the northern and eastern regions. This assumption is substantiated by the change in the thickness of the super-Vereian carbonaceous series, established by seismic prospecting. The reduction in the thickness takes place to the east along the flexure of the western rim of the Cis-Ural foredeep from 700-900 meters, and at the section of the flexure of the northwest course from 600 to 300 meters. On the basis of this, the development of the biohermic formations of the Lower Permian age in the Sol'-Iletskiy region should be expected in zones with a sharp change in the thickness.

The characteristics presented of the geological structure of the Sol'-Iletskiy region, according to the data from drilling and seismic prospecting, make it possible to determine the basic directions in exploratory-prospecting work.

1. The prospects for discovering new deposits of oil and gas in the south-eastern part of the Sol'-Iletskiy anticline should be related to the uplifts that have a tectonic origin and to the complicated biohermic structures of the Lower Permian Age in a belt about 20 kilometers wide along the western rim of the Cis-Ural foredeep. It is here that there may be developed high-amplitude local uplifts with improved collector properties of the Lower Permian carbonaceous deposits, through developing biohermic structures, as well as reliable covers for the formations in the Bashkir stage.

2. In the adjacent part of the Cis-Ural foredeep, the deposits of the Bashkir stage and lower-lying carboniferous formations are promising for seeking oil and gas deposits. The rock mass of interstratified dense, microgranular, argillaceous and silicified limestones, argillites and marls of the Vereian horizon or the argillaceous-carbonaceous deposits of the Lower Permian period serves as a cover for the porous limestones of the Bashkir stage.

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FUELS AND RELATED EQUIPMENT

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PREDICTING, PREVENTING MINE SHOCKS IN CENTRAL DONBASS REGION

Kiev UGOL' UKRAINY in Russian No 6, Jun 79, pp 37-38

[Article by D. I. Khodyrev, engineer, VNIMI [All-Union Scientific Research Institute of Mine Surveying]]

[Text] In the mines of the Central Region of Donbass when mining reaches depths of 320 t0 600 meters on nondischarge-dangerous, steep very thin seams m^2_6 Novyy, m^0_4 Zaychik, l_5 Solenyy, l_3 Mazurka and h_{10} Babakovskiy, there is a dynamic phenomena in the form of a coal outburst when the coal is extracted. Previously, it was considered that these outbursts in their nature and manifestation are different in principle from mine shocks [1, 2] . However, as the depth increases, these coal outbursts more frequently grow into microshocks and mining shocks. During 1973-1977, in the Artemugol' Association when mining seams m^0_4 and l_5 in mines imeni Gagarin, imeni Lenin, imeni Dzerzhinskiy,"Komsomolets" and "Novo-Dzerzhinskaya," six microshocks and mine shocks were recorded with an intensity of from 3 to 15 tons. Thus, in the Central Region of the Donbass, the facts of the qualitative transition of one form of mine shock into another -- outbursts of coal-microshocks-mining shocks, [3, 4] detected by the VNIMI in other coal deposits in the country are confirmed.

To clarify the nature of the dynamic phenomena in the above-mentioned seams, the shock danger was forecast by the yield of drilling fines from exploration holes 42mm in diameter. Fig. 1a shows results of the forecast which were used to establish categories (I and II) of whock danger of seam l_5 in the mine im. Gagarin. This data confirms a microshock which occurred when the coal was mined by a pneumatic drill on shelf No 2 in this seam the day after the drilling of exploration holes. The microshock was manifested by the crumbling of the edge of the seam and the coal falling down from a height of up to five meters due to the strong tremor of the mountain massif (Fig. 1b).

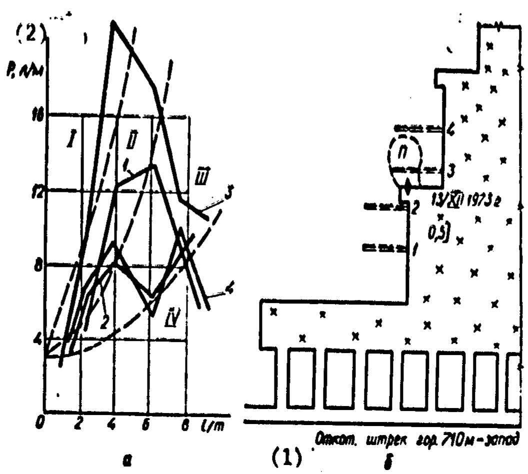

Fig. 1. Forecast of shock danger (a) and arrangement of exploring holes No 1-4 (b) in seam 15 of mine imeni Gagarin. I, II, III, IV -- categories of shock danger; l -- length of hole; m -- thickness of seam; p -- yield of drilling fines; Π -- cavity of falling coal; black rhombus-- place of mining shock.

1. Haulage drift mine 710-West. 2 -- [?]

A characteristic feature of mine shocks on rectilinear sections of stopes where conditions are created for more uniform stress distribution is a small area in the (1 to 2m^2) breakup of the edge part of the seam. In the backs of the ore blocks of ledge-like longwalls, the mine shocks develop in the zone of maximum bearing pressure and are usually accompanied by breaking up (falling) coal at a height of 3 to 15 meters. A list of dangerous seams threatened by mine shocks was determined by the results of forecasting the shock danger and analyzing the dynamic phenomena (micro-shocks, jars in the massif, outbursts of coal) in the process of mining. They were developed by using the measures indicated in the Table.

Table

(1) Шахты или ш/у	Глубина, на которой начались горные удары, м	(3) Пласты, разрабатываемые с применением (4) прогноза удароопасности	восстающих (5) разгруз. скважин	(6) гидрообработки	(7) механ. выемки угля
«Кочегарка» (8)	750	l_3	—	—	—
Им. Ленина (9)	620	l_5	—	—	—
	750	—	l_6^*	—	—
«Комсомолец» (10)	740	—	m_4^{0*}	—	m_4^{0*}
Им. Гагарина (11)	591	—	—	m_6^2	—
Им. Калинина (12)	630	—	l_6	l_8	—
Им. Румянцева (13)	610	l_8	—	—	—
	730	l_3	—	—	—
Им. Дзержинского (14)	816	—	m_4^{0*}	—	m_4^{0*}
«Ново-Дзержинская» (15)	220	--	m_4^0	—	m_4^0
Им. Гаевого (16)	740	i_8	—	—	—
«Александр-Запад» (17)	500	—	—	l_8	—
Им. Артема (18)	860	l_5	—	—	l_8
Им. Изотова (19)	830	m_4^0	m_4^0	—	—
«Красный профинтерн» (20)	865	l_8	—	—	—
№ 3	560	—	—	—	l_6^*
(21) Итого . . .		8	6	3	5

Note. Dangerous seams indicated by asterisks, others -- threatened by mine shocks.

1. Mines
2. Depth at which mine shocks began to occur, m.
3. Seam worked, using
4. forecast of shock danger
5. reconditioned by relief holes
6. hydraulic mining
7. mechanical mining
8. "Kochegarka"
9. Imeni Lenin
10. "Komsomolets"
11. Imeni Gagarin
12. Imeni Kalinin
13. Imeni Rumyantsev
14. Imeni Dzerzhinskiy
15. "Novo-Dzerzhinskaya"
16. Imeni Gayev
17. "Aleksandr Zapad"
18. Imeni Artem
19. Imeni Izotov
20. "Krasnyy profintern"
21. Total

Experimental work, and an analysis of dynamic phenomena in the mines of the region established that the most dangerous sections of the longwall are its bottom part (30 to 40 meters from the hauling drift) and the upper part (10 to 20 meters from the ventilation drift). To reduce the laboriousness of forecasting the shock danger, it is enough to drill exploration holes only in the backs of the ore blocks of the first, second and the one before the last ledges of the longwall every 10 to 15 meters, and when extracting coal in zones of geological breakup or where there is erratic behavior of the seam -- every two to three meters. On ledges where individual signs of shock danger appear (cracks, shocks in the massif, change in the efficiency of the pneumatic hammer or drill when penetrating the seam), it is necessary to forecast the shock danger quickly.

In the Central Region, the seams subject to mining shocks lie in various formations and, not being discharge dangerous, are utilized as protective seams. Therefore, for fighting mine shocks basically local measures are used: injection of water into the seam to wet and compress the seam hydraulically, and drilling relief holes. Due to the low general porosity of the coal, the minimum value of which in most seams prove to mine shocks is 1.7 to 2%, deep wetting was found to be ineffective. The introduction of hydraulic compression in stopes when thin steep seams are mined is limited by technological complications and imperfect equipment. Therefore, relief holes are (vertical) used widely in the region (see Table).

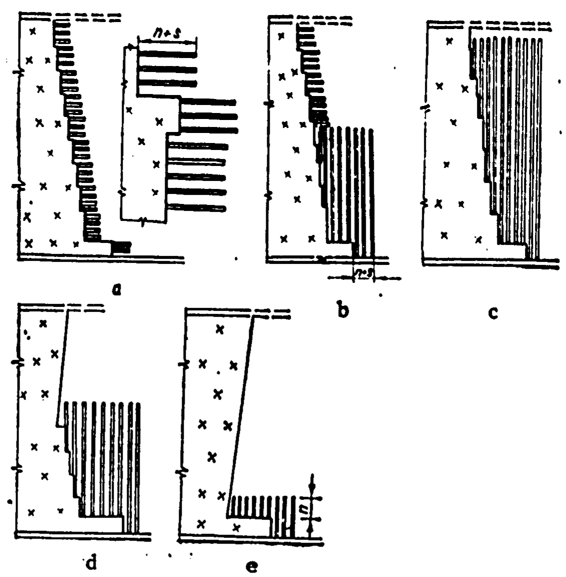

Fig. 2. Arrangements for drilling relief holes: n -- width of protective zone; s -- movement of the longwall during one cycle.

Compared to other coal basins in the country, holes 150 to 300 meters in diameter in the Central Region of Donbass have a smaller radius of relieving action (not over 0.5 meters), which is due to thinness (up to 0.5 meters) of the mined shock-dangerous seams.

Relief holes are drilled according to arrangements by the VNIMI. In longwalls with top-ledged shape of the stope, drilling of horizontal holes in specified Fig. 2a) along with horizontal in combination with vertical holes (Fig. 2b) and vertical holes (Fig. 2c). In longwalls, where mining machines are remote controlled, no antishock measures are specified because people are at a safe distance from where the coal is cut. In this case, relief holes are drilled only in the ledge part of the longwall (Figs 2d and 2e). Due to great laboriousness relief holes are used only in individual cases, when other versions are impossible. Experience established that categories I and II of shock danger occur in individual sections where partial use of the version in (Fig. 2a) is recommended. When drilling vertical relief holes (Fig. 2c) in the hauling drift by means of machines (LBS, BIK, etc.) it is possible to combine any work on coal extraction from the stope, but long holes in the upper part may twist. Therefore, the most acceptable is the version shown in Fig. 2e in which the holes hardly curve. The effectiveness of antishock measures, including relief holes, is evaluated by the yield of drilling fines from control holes, i.e., by the same method as in forecasting the shock danger of the seams.

As a result of investigations and experience in working seams prone to mine shocks, parameters were determined for antishock measures which apply to conditions of the Central Region of Donbass. However, the great laboriousness frequently serves as a reason for not fulfilling the measures. The most promising measure for protection against mine shocks is extracting coal with remote controlled machines. This is attested to by the practice of working shock-dangerous seams m^o_4 and l_5 with combines at the "Komsomolets" Mine imeni Artem and at the "Aleksandrovskoye" Mine No 3. Mechanized coal extraction, aside from creating safe working conditions, makes it possible to utilize the energy of mine shocks to make the mining process easier. Successful mining of shock-dangerous seams by means of cutting machines and cable saws in the Kizelovskiy basin and KMP-2 cutting machines with remote control on the m^o_4 seam of the "Novo-Dzerzhinskaya" Mine confirmed the promising future of mechanized coal mining in insuring labor safety and reducing the power needed for coal mining.

The stressed edge part of the seam where a slot is cut is subjected to the action of elastic expansion forces, while ahead of the cut in the slot it is subjected to additional compression. The greater speed of change in the stressed condition, occurring in this case, above the maximum possible speed of seam transition to the limiting condition by plastic deformation produces a brittle collapse of the coal throughout the thickness of the seam in the form of microshocks. Their intensity and the area of coal collapse may be regulated by the depth and speed of penetration of the seam by the working members of the mining machines.

The dissemination of mechanized coal mining is complicated by the thinness of the seams, geological dislocations, the presence of sections with weak side rocks and the inadaptability of existing coal mining machines to regional conditions. When coal is mined with pneumatic hammers, where there are no antishock measures or measures are not properly taken, labor conditions are especially dangerous for workers in a restricted working space near a possible mine shock. Therefore, in seams prone to mine shocks, it is necessary first of all to specify mechanized coal mining.

Conclusions. With greater depth of mining, the dynamic phenomena of coal discharge develop into microshocks and mine shocks. In this connection, a list of mine seams prone to mine shocks was determined. These are mined using forecasting of shock danger and with measures taken in dangerous zones. Relief holes became widely used for preventing mine shocks. The most promising for creating safe working conditions in seams prone to mine shocks is mechanized coal mining with remote control.

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FUELS AND RELATED EQUIPMENT

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NEW WAY OF FIGHTING SUDDEN DISCHARGES OF COAL AND GAS

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[Article by V. L. Bozhko, M. I. Bol'shinskiy and I. I. Balinchenko, candidates of technical sciences MakNII [Makeyevka Scientific Research Institute for Work Safety in the Mining Industry] : A New Direction in Solving the Problem of Fighting Sudden Discharges of Coal and Gas"]

[Text] Regional and local measures are used to fight discharges of coal and gas. The first are implemented ahead of time, therefore, they do not disrupt and inconvenience mining, while the second are implemented from the stope side of the drifts and are unavoidably included in the technological cycles of stope and shortwall work.

At present, advanced working of protective seams (as a regional method) is used at 49 stopes and 56 shortwalls with full protection and at 63 stopes with partial protection. When partial protection is used, local measures or various technological measures are used, for example, opening up the seam from the field drift by means of inclined blind shafts above the production line, finishing off the unprotected part of the seam without taking any measures, but under safe conditions, etc.

An analysis showed that a considerable increase in the volume of advanced finishing off of protective seams is not expected in the very near future. Other regional methods such as degassing and moistening seams through long holes, drilled ahead of the stopes, are also being introduced in limited volume, i.e., only at 5-10 drifts which is due basically to the lack of facilities for the drilling of long holes in discharge-dangerous coal seams. In 4 Donbass mines, a method is being studied for reducing the discharge dangers and the amount of gas in the seams by breaking them up hydraulically. In mines imeni Kalinin and imeni Skochinskiy (Dentsugl' Association), they are working in the zone where the seams are broken up hydraulically, however, it is still impossible to judge the efficiency of this method.

Thus, at Donbass mines, of the regional methods, advanced working of protective seams with full protection and that only at 9% of the stopes and 14% of shortwall drifts is used basically; at the remaining stopes various measures of a local nature are being implemented.

Local antidischarge measures -- hydraulic loosening and hydraulic squeezing of seams, forming hydraulic grooves and others -- are implemented constantly at 100 stopes and 80 shortwalls and periodically in dangerous zones in drifts which is done when a current prognosis is available. Measures on creating safe conditions in cases of the origination of sudden discharges of coal and gas when doing concussive blasting are utilized at 55 stopes and 115 shortwalls and remote control when mechanized coal mining is done, at 88 stopes. Many years of experience indicated that all these measures have fairly high reliability. In five years (1974-1978), the number of sudden discharges has almost halved, while injuries related to discharges decreased to less than a third.

All local measures are intended to relieve and degas the part of the seam near the stope; after their proper implementation, the danger of discharges and the possibility of sudden discharges are reduced greatly. However, they have essential shortcomings: they are laborious, must be done from the stope side and, therefore, enter the technological cycle of mining. The situation became especially complicated in connection with the introduction of shield units on steep seams and planing installations on gently-sloping seams. The design of these installations does not provide for using antidischarge measures from the stope side, especially with thin seams. It was assumed that when coal is extracted by shavings 6 to 7cm wide, its breakup would occur in the relieved and degassed zone near the stope, i.e., it would be possible to avoid freeing the discharges even without taking antidischarge measures. All of that should have facilitated creating safe labor conditions and increasing the technical-economic indicators of stope work.

At present, shield units operate at 40 stopes of steep seams at mines of the Ordzhonikidzeugol' and Artemugol' associations.

Eight sudden discharges occurred at stopes with shields and a great number of gas-dynamic phenomena of the squeeze-out type with a high gas discharge. Some 27 longwalls with discharge-dangerous gently sloping seams are equipped with planers; 27 of them have a seam thickness of less than 0.8 meters because of which antidischarge measures are not used there. Some 19 sudden discharges occurred where planers were used for mining. Their analysis indicated that 18 discharges occurred when the coal was mined, not along the entire length of the longwall, but by sections, i.e., when there was a high speed penetration into the coal mass.

Therefore, mining coal by means of shields and planers without antidischarge measures does not prevent discharges; it is not always possible without people around.

An increase in the number of stopes equipped with combines (with remote control), shield units and planer installations, and operating without antidischarge measures, as well as stopes with coal mining by means of BVR [expansion unknown] in the mode of concussive blasting, led to an increase in provoked discharges from 85 in 1974 to 163 in 1978. It was established that with a constant action on the seam (formation of continuous relief slots and cavities) more efficient and relieving and degassing are achieved than in the discrete method (advanced holes, torpedoing and hydraulic working of the coal through holes). The effect of the first method is similar to protective finishing off and it is not necessary to monitor the reliability of antidischarge measures.

The truth of this is confirmed by the experience of finishing off discharge-dangerous seams with preliminary undercutting of coal by a cutter machine. In 25 years (from 1953 to 1978 inclusive), only ten sudden discharges of coal and gas were recorded during operation of the cutter machines in discharge-dangerous seams in 186 longwall for a total movement of 40,000 meters of the stope line. After undercutting, when mining coal by a value not exceeding the depth of the cut, not one discharge occurred.

Discharges during the formation of the relief slot can be prevented by changing the speed of making it and its depth.

Experimental work is being done on the fifth eastern longwall of the l_3 Almaznyy seam of the "Sadovo-Khrustal'skiy" Mine (Dombass-antratsit) to check the above statements on the effect of the relief slot on the part of the seam near the stope and work out the parameters of safe formation of the relief slot and the technological effectiveness of preventing discharges. In view of the lack of special devices, the slot is cut from the bottom up by the "Ural - 33" cutting machine (bar length is one meter), which is moved along an SP-63 conveyor. For a longwall, 180 meters long and for the time spent on forming the relieving not exceeding two to three hours, investigations showed that the seam within the limits of the slot is fully relieved and degassed. The extraction of the undercut band of coal is done by a 1K-101 combine with a grab depth of 0.8 meters and in a one-sided arrangement. As the combine moves from the top down, the longwall is trimmed, the cutting machine is transported to the lower position and the process is repeated.

Experimental work done at the "Sadovo-Khrustal'skaya" Mine confirms the possibility and feasibility of changing over to a technology of coal extraction with a relief slot all along the longwall. The advantages of this are: higher reliability of eliminating discharges along the entire length of the stope; monitoring the effectiveness of the antidischarge measure is not necessary; a reduction in the special time spent on taking antidischarge measures and the possibility of using remote control devices for forming the relief slot.

Investigations must be further continued on finding the relief slot parameters and the technology of its creation. To insure the fastest introduction of the new methods for fighting discharges, the Giprouglemash and Dongiprouglemash must develop machines for making the relief slot when using combines and planing machines on gently sloping seams, and shield machines on steep seams. One method for forming relief slots along the entire length of the stope may be undercutting the seam zone near the stope with cable saws; its basic shortcoming is the cable saw being clamped by the coal fines when the coal is undercut on large areas. However, in the case of using the cable saws in combination with coal extraction machines (combines, planers, shields), it is necessary that in each extraction cycle, the seam should be penetrated less than 1 to 1.5 meters. In such a case, clamping of the saw is eliminated. The measures described above are to be used for preventing sudden discharges at stopes and are not practical for niches. Their greatest effectiveness will be in longwalls worked by the pillar system in which the seam at the end sections of a stope is relieved and degassed. The use of continuous systems on seams dangerous with respect to discharges should be considered an exception, while extraction from niches in such cases is permitted only by concussive blasting.

The new way to prevent discharges will unavoidably result in some modernization of the existing mechanized extraction from steep seams. It is obvious that it is urgent to improve designs of the AShch and IANShch machines in order to increase the power of conveyor-planers by installing two electric motors. This will require preparatory methods for outlining the sections for shield extraction by means of coal and ventilation chutes. Such chutes can be safely constructed by the KMD-72 machine of the Dongiprouglemash design.

On steep seams where coal is extracted by combines mechanized supports and complexes must be used. It should be noted that even when the described measures are applied to steep seams, it will still be necessary to finish off a longwall with roof-bench stopes by using pneumatic hammers under complicated mining-geological conditions in individual cases. As shown by experience, the best antidischarge measure is forming relief slots in the seam. While the use of known local antidischarge measures leads to a reduction in seam stability which, in individual cases, especially on steep seams, may facilitate its breakup, the formation of relief slots not only does not weaken the coal mass but it may be possible to install an advanced support to support the overhanging mass. Wide introduction of the given method is being delayed by the lack of series production of machines for forming relief slots in the seam. The Uglemekhanizatsiya Scientific Production Association will develop in the very near future an installation for tunneling relief slots in steep seams.

The use of the principles described above to prevent discharges and improve the technical-economic indicators in making shortwalls by selective action combines in seams, where dangerous discharges are possible (mixed stopes containing rocks with hardness six on the Protod'yakonov scale), was realized in the following method. It was based on forming relief cavities in rocks by first extracting rocks by the combine and later extracting coal from the relieved and degassed zone of the seam near the stope. Moreover, MakNII jointly with the TsNIIpodzemmash developed a technical project on the creation of a universal UShch-IE machine for shortwalls, which must do the following operations: form relief slots for preventing discharges during coal mining, drill coal and drill bore holes in rocks. The introduction of Ushch-IE will make it possible to use it not only to prevent discharges from relief slots in shortwalls containing strong rocks, but also fully mechanize tunneling.

Conclusions. To increase the safety and technical-economic indicators of mining in unprotected discharge-dangerous seams, it is necessary to change over from local methods of fighting discharges to a special technology for stopes and shortwalls (forming continuous relief slots or cavities in the seam or in the rocks around the seam by mining, tunneling or special machines). To implement the new antidischarge measures widely, it is necessary to accelerate the creation and manufacture of modernized mining as well as tunneling equipment and special installations.

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